

**HYPERLOOP:** WOULD YOU TRUST TUBE-TRAVEL AT 1200 KM/H?

AUSTRALIAN

# POPULAR SCIENCE

**BLOCKBUSTED!**

HOLLYWOOD SCI-FI  
PUT TO THE TEST

## THE FUTURE OF WAR

BY LAND



BY SEA

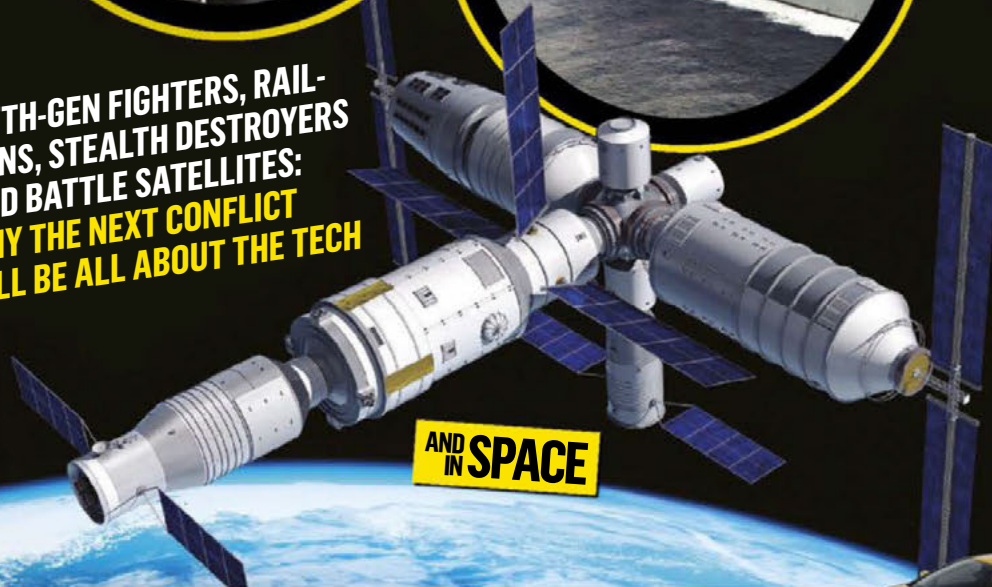


BY AIR



FIFTH-GEN FIGHTERS, RAIL-GUNS, STEALTH DESTROYERS AND BATTLE SATELLITES:  
WHY THE NEXT CONFLICT  
WILL BE ALL ABOUT THE TECH

AND  
IN SPACE



**PLUTO'S FIGHT**

Why we're better off  
with just 8 planets

**EXPLOIT 4G!**

Our hacks to get the  
most from your mobile

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Build a motion detector · Make your backyard smart  
Evolve beyond email · Thrash the Ford Focus ST (for science)





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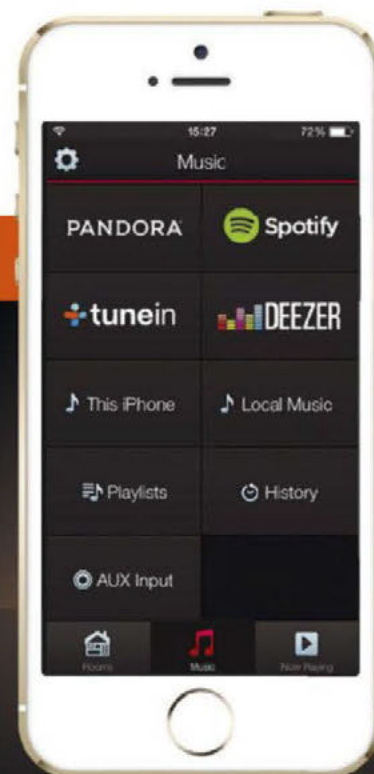
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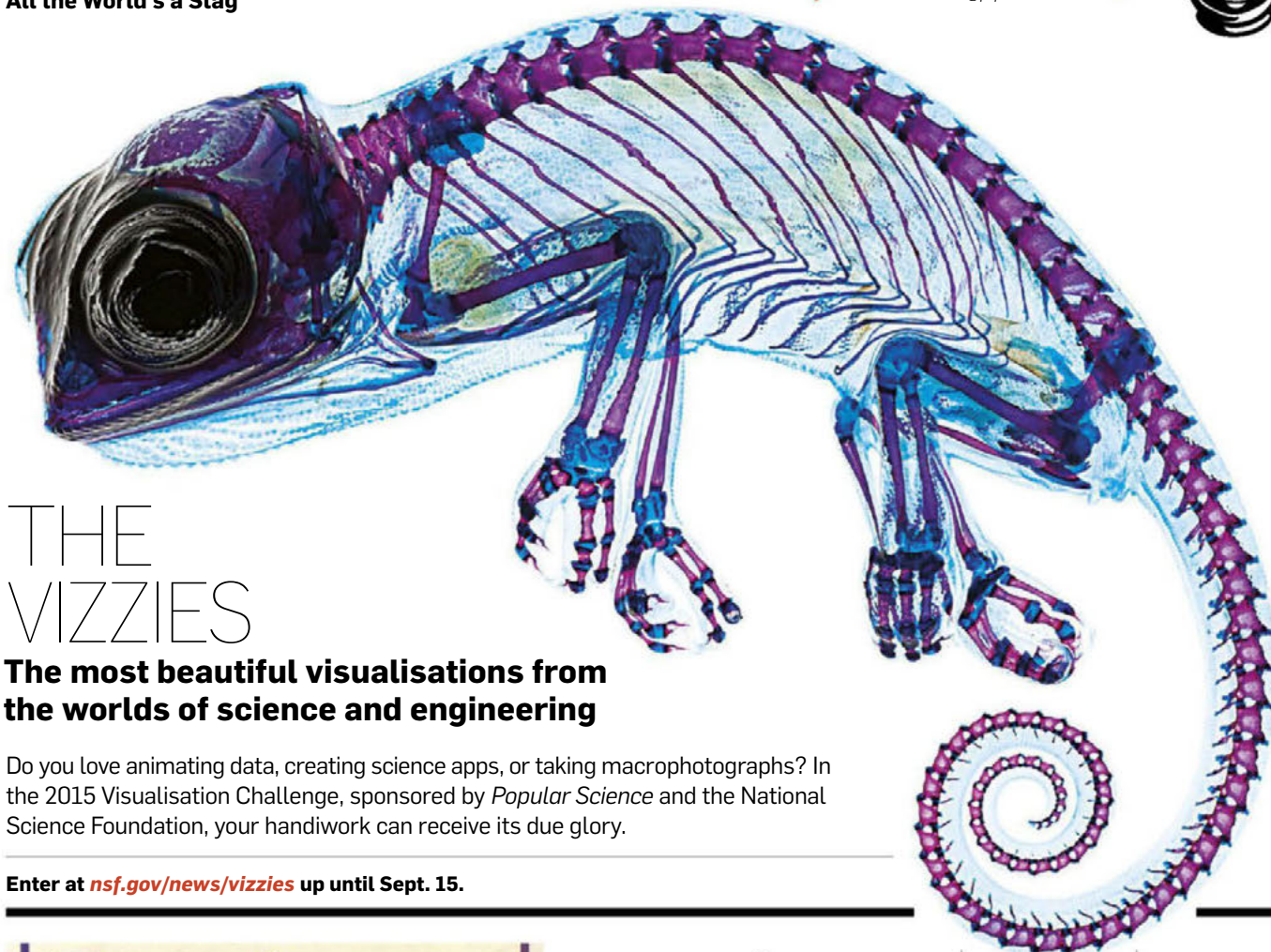


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### HOW HISTORY HELPS US VIEW THE FUTURE

It doesn't hurt to have an archive filled with 143 years of science and technology. It was precisely that history that inspired the design of our hyperloop feature. This cover from October 1930 wowed readers with an early monorail concept.

### Q: WHICH SCI-FI LOCALE DO YOU WANT TO VISIT THIS SUMMER?

1 Tatooine. I've always wanted to see that double sunset, and I hear Tosche Station is hopping this time of year.

2 The planet Uriel from *A Wrinkle in Time*, so I can visit the Mrs Ws

3 Narnia! Mr. Tumnus was a hybrid man-goat species; that makes it sci-fi, right?

4 The new Area 51—Dugway Proving Grounds outside Salt Lake City

5 I wish Jurassic Park were real and not fatally dysfunctional. A smoothly run Jurassic Park. One can dream.

6 Considering I love winter, I'd go to Jotunheim from Thor (where the frost giants live).

7 Milliways, the Restaurant at the End of the

### TEST SUBJECTS

In the midst of producing this issue, the NY Mothership hosted Take Your Child to Work Day. Lucky for them, that meant they had plenty of (tiny) helping hands to test the make-your-own smoke rings project on page 76.





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The risk of conflicts between great powers is rising. How will that change the battlefield of tomorrow?  
**P.W. SINGER**

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A near-supersonic commute might arrive sooner than you think. Startups are racing to bring the hyperloop to life. **JAMES VLAHOS**  
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This year's sci-fi blockbusters are so bizarre, they must be fiction. Right? We asked the experts. **ERIK SOFGE**  
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Tired of mowing the lawn? Learn how to build a more efficient, automated home from the outside in. **CORINNE IOZZIO**  
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# NEW-TECH'15

JULY 31-AUG 2 | SYDNEY SHOWGROUND

EXPERIENCE LIFE-ENHANCING TECHNOLOGY  
AT AUSTRALIA'S NEW TECH EVENT!

THERE IS SOMETHING  
FOR EVERYONE  
AT NEW-TECH!

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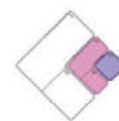
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## Depressingly Clever

**Despite our Future** of War cover, I'll resist the urge to trot out all those statistics about how if we'd saved the money from the last decade or so of wars, we'd have enough to build 10 Apollo programs, or a tunnel between Los Angeles and Hawaii. But keep in mind: as cool as all this military technology is, at the end of the day we're still talking about tools for killing people.

Since World War II though, there's been this assumption that "war is good for business". Certainly, winning WWII did a lot for the US economy, but today's economists are quick to point out that if the global leaders of the 1930s had (somehow) managed to avoid war altogether, the US economy would have done even better.

It stands to reason. Millions of workers wouldn't have died, and money and resources spent on building machines just so they could get blown up, could have been spent on more useful things. Like Martian colonies in the 1960s.

Not that we could have avoided World War II, in reality. And if the US had maintained its isolationism and refused to fight, it probably would have left the country as an economic backwater. Or who knows, this kind of speculation is only fun for writers of alt-history fiction.

One of the more unfortunate side-effects of the great conflicts of the 20th century has been President Eisenhower's military industrial complex (well, not HIS, the one he warned us about). Basically, the wars made the business

of building tools to kill people so huge, it became almost impossible to dismantle the industry after peace returned. In fact, the so-called "hawks" in various governments around the world even went so far as to redefine peace, to keep the production lines running. Sorry, that's cynical: these guys honestly believed in the dangers they saw coming from every corner of the globe and felt the best line of defence was to build more tanks. Or nukes.

Flip forward 40 years, and the US is now in a situation where everyone is arguing about the budget overruns on a military aircraft (the F-35) which will replace another military aircraft (the F-22) which has done almost no fighting. During WWII, the big aerospace companies had to iterate models and versions over and over to meet constant threats. They built thousands of Spitfires and Hurricanes and Corsairs and Wildcats, with dozens of mission profiles and variations. For men (and it's almost exclusively men) who like designing and building warplanes, the war was great.

Today, those companies still

exist and still want to do what they do best: build fighting aircraft. But there are only 195 F-22s, and they have no one to fight. It's making the whole thing seem stupid.

In this issue, we profile the future of war. We talk about all the great toys the army men will get to use, but only IF there's another massive conflict between powerful states. Against terrorists or insurgents or whatever you want to call them, most of this stuff is pointless. Keyhole satellites, drones, lightweight body armour and intelligence gathering tech - that's what we actually need. A military space station? Who is that for?

Of course I'll change my tune if a big conflict does kick off. And I'm more than aware I'm speaking as a citizen of a nation allied with the US. I can strut about accusing the yanks of wasting money on the world's most technologically advanced military kit, secure in the knowledge that it's out there, somewhere, in the event we ever need it.

That's the problem with the military industrial complex. It's almost a pointless waste. But the frighteningly operative word here is "almost". Fingers crossed that space station gets mothballed without ever firing an orbital laser.

### ANTHONY FORDHAM

afordham@nextmedia.com.au  
@popsciau

# POPULAR SCIENCE

Issue #80, July 2015

### EDITORIAL

Editor Anthony Fordham [afordham@nextmedia.com.au](mailto:afordham@nextmedia.com.au)  
Contributors Lindsay Handmer

### DESIGN

Group Art Director Kristian Hagen

### ADVERTISING

#### Divisional Manager

Jim Preece [jprece@nextmedia.com.au](mailto:jprece@nextmedia.com.au)  
ph: 02 9901 6150

#### National Advertising Sales Manager

Lewis Preece [lpreece@nextmedia.com.au](mailto:lpreece@nextmedia.com.au)  
ph: 02 9901 6175

#### Production Manager

Peter Ryman

#### Circulation Director

Carole Jones

### US EDITION

Editor-in-Chief Cliff Ransom

Executive Editor Jennifer Bogo

Managing Editor Jill C. Shomer

### EDITORIAL

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Senior Associate Editor Corrine Iozzio

Assistant Editor Lindsay Kratochwill

### ART AND PHOTOGRAPHY

Art Director Todd Detwiler

Photo Director Thomas Payne

### POPSCI.COM

Digital Content Director Dave Moshier

Senior Editor Paul Adams

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Peer Review

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2015



## KEEP IT ON THE DOWN-LOW

I am very much in favour of faster, more-efficient lifts ["An Elevator That Will Reshape Skylines"]. But that does not mean we should build even taller structures. There are many reasons not to go higher: fire fighting, evacuation, natural disasters, and eventual demolition immediately come to mind. Just because we can do something doesn't mean we should. **John Corcoran**

### DRONE-VERDOSE

I appreciate all that you guys do to keep the average individual informed. But I don't think I'll be the first to say: Enough with drones!

**John Froese**

**We apologise...** In the May issue, the battery capacity of the C-1 should have been listed in kilowatt-hours. And the diode referenced was one of the germanium variety, rather than geranium. Flowers don't make for great circuits.

## TWEET OUT OF CONTEXT

**Thanks, now I feel better about the fact that I've been too lazy to walk across my own continent to throw something into a volcano.**  
@theurbansherpa

### BIOACCUMULATION ISSUES ASIDE...

The article on entomophagy ["The Rise of the Incredible, Edible Insect," May 2015] got me wondering how this environmentally friendly trend could be improved even more. Are there any bugs that could feed off landfills? Then we'd be killing two birds with one stone: reducing our waste by harvesting more food for ourselves.

**Ben Sandeen**

### ALMOST FAMOUS

I wanted to send a quick thank-you to the entire team for one of the most

incredible moments of my life! Humbled and grateful,

**Katarzyna "Kasia" Sawicka**

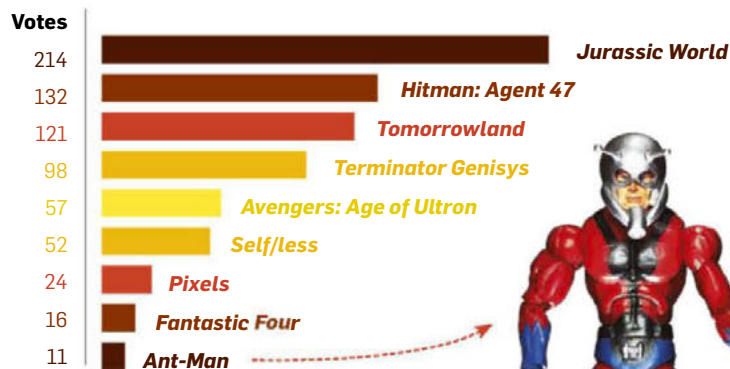
[Featured inventor in the 2015 "Invention Awards," May]



HAVE A COMMENT?  
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Level 6, Building A,  
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## SCIENCE-FICTION SHOWDOWN

Which 2015 Sci-Fi flick do PopSci readers think is most true to science? (Deary, deary me...)



To find out how close the movies actually get, check out "Weird Science" on page 48.

## Show & Tell

On page 60, we explain how to hack your backyard. But there are plenty of tinkerers already out there. Send us a photo or description of the smartest upgrades you've seen on a neighbour's lawn—or your own.



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## THE PERFECT PROJECTOR FOR STREAMING



**Setting up** a backyard movie screening sounds like a great idea—until you try it. You need an outlet or extension cord, and even more cables to connect a computer or streaming box to your projector. The ZTE Spro 2 frees you from that. An update to last year's original Spro, the portable projector has a 200-lumen bulb—double that of its predecessor. A full Android operating system makes it an all-in-one device with touchscreen navigation to load the latest movie and

project it at a size of up to three metres on the diagonal.

There's no need to worry about spotty Wi-Fi slowing down streaming because Spro 2 creates its own hotspot for up to 10 devices using

4G LTE or a wireless network. It can also connect wirelessly to your computer or streaming box thanks to Bluetooth, or serve up videos straight from its 16GB hard drive or apps available from the Google Play store. To get the full cinema experience, add your favourite wireless speaker and enjoy your own backyard theatre under the stars. **RACHEL FOBAR**







## **FOCAL – THAT'S FRENCH FOR BETTER SOUND**

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# Obsessed

Some things are just...better

LINDSEY KRATOCHWILL

(Prices are shown in US dollars... remember when that used to mean cheapness? Ah the ups and downs of modern life...)

## 1 VAPOURLIGHT HYPER SMOCK 2.0

On long hiking trips, every gram matters, so Berghaus has created the lightest-weight waterproof jacket yet. At a mere 85 grams for a size large, it's roughly 30 per cent lighter than its nearest competitor. **\$150**

## 2 TRAINER BY GIBSON

Legendary guitar maker Gibson worked with Olympian Usain Bolt to develop wireless over-ear headphones for runners. Built-in LEDs in the earpieces increase nighttime visibility. At the touch of a button, you can also lower the volume to stay alert during your run. **\$250**

## 3 STOWER CANDLECHARGER

With Stower's Candle Charger system, a single Sterno canister can charge a smartphone—twice. The candle's flame heats and purifies a pot of water, which serves as a thermoelectric generator. **\$99**

## 4 MISFIT SWAROVSKI SHINE

Who says you can't count steps at a black-tie event? Misfit's newest activity tracker comes with a Swarovski crystal face and can be worn with nine different accessories, so it will fit in with your wardrobe whether you're at the gym or next year's Met Gala. Caaaack. **From \$169**

## 5 BIG SCIENCE

Pulitzer Prize-winner Michael Hiltzik tells the tale of a Nobel Prize winner: Ernest Lawrence, who created the Cyclotron. *Big Science* chronicles how Lawrence's early particle collider helped to revolutionise nuclear physics. **\$30**

## 6 MILWAUKEE M18 JOBSITE FAN

Milwaukee's new jobsite fan moves air at 8000 litres per minute and can run on battery power for up to 17 hours—enough time to dry wet paint and plaster on the job. It can also swivel 120 degrees, so you don't need to constantly reposition it. **\$79**

## 7 TOMTOM BANDIT ACTION CAMERA

TomTom's Bandit lets you edit on the go—no need to download footage onto a computer. Motion and GPS sensors tag your most extreme moments, and a companion smartphone app turns them into a highlight reel. **\$399**

## 8 COLOR ALIVE

Title, sic. Crayola's new app can capture masterpieces and turn them into animated 3D figures. Kids can play with their creations in the app, and even take selfies with them. **Free**

## 9 POPSLATE

Snapping this case onto an iPhone 6 adds a shatterproof ePaper screen to the back of the device. The popSLATE can last for seven days on a single charge. **\$129**



6



8



4



9

## 10 GEEKS WHO DRINK

Syfy's latest show is like a trip to the bar on trivia night—except you get to watch from your couch. Hosted by Zachary Levi, hero of the spy comedy *Chuck*, the weekly game show grills geeks on topics like pop culture and science fiction. Pick up a few pieces of awesomely nerdy knowledge to impress your friends the next time you're making conversation at a cocktail party. **July 16**



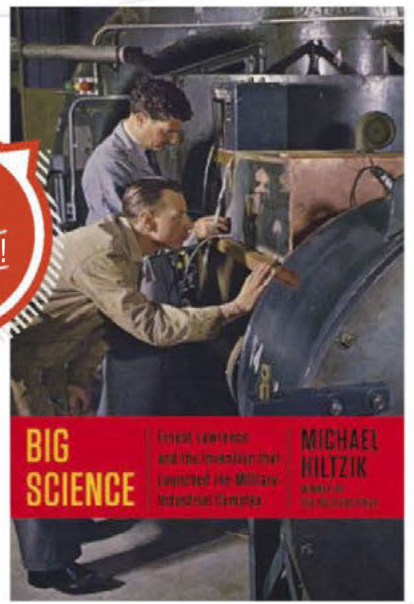
FROM TOP LEFT: COURTESY GIBSON; COURTESY BERGHAUS; COURTESY MILWAUKEE TOOL; COURTESY POPSLATE; COURTESY NBCUNIVERSAL; COURTESY TOMTOM; COURTESY CRAYOLA; COURTESY SIMON AND SCHUSTER; COURTESY MISFIT; COURTESY STOWER





HIGH-ENERGY PHYSICS!

5



# VECTOR YOUR TORQUE IN A 184 KW HOT HATCH

↓  
**To demonstrate the** new stability of the LZ-model Focus ST, Ford invited us to push the car around a custom track set up at Eastern Creek raceway. From slaloms to high speed cornering, the name of the game was getting around as quickly as possible, and not sliding off or spinning at every apex. Actual driving skill optional.

The boffins at Ford gave the ST chassis a dynamics makeover, starting with a six-speed manual transmission (no auto option, so you know it's serious), new springs, sportier damper

**The torque vectoring system** analyses the relative speed of each powered front wheel, detects whether a wheel is losing traction, and applies the brake to correct the turn. Supercars use regenerative braking to achieve the same effect with much more precision.



characteristics and an improved electric power steering system. But the real cornering stability comes from that torque-vectoring system. In basic terms, when the ST is thrown (no doubt a little too hard) into a corner and the driver then jumps on the power, because it's a front-wheel-drive car, there is a tendency towards understeer and loss of traction on the inner front wheel.

The car actively monitors the situation and will step in to maintain traction and ensure maximum power gets to the ground. The trick is done by actually using the brakes - the ST will apply braking torque on the inside wheel to help steer in harder and stop it spinning. In essence the system works a bit like an electronic limited-slip diff, except by individually triggering the front brakes.

So how does it actually feel on the track? In many ways it is seamless and barely noticeable. Instead of understeering into the cones defining a sharp (and in one case, water coated) corner, the car turns in hard

# 270

**Limited top speed, in km/h, of the fastest hot hatch available in Australia today, the Mercedes A45 AMG. It costs \$75,000.**



## 2015 FORD FOCUS ST

**Engine:** 2.0L 4-cylinder turbo

**Power:** 184 kW @ 5500 RPM

**Torque:** 360 Nm @ 2000-4500 RPM

**Top speed:** 238 km/h

**Transmission:** 6-speed manual

**Economy:** 7.3 L/100km

**Price:** \$38,990

**URL:** [www.ford.com.au](http://www.ford.com.au)

and maintains traction when the accelerator is mashed. For normal driving, the car feels a little less refined but the agility makes up for it. Winding our way along the Old Pacific Highway, the most noticeable thing was how the drivetrain handled full power on the rough road. On this less than ideal everyday surface, torque steer was at times quite noticeable.

Will torque vectoring wear out your brakes quicker? Sure, but the safety and handling bonuses make it more than worth it. A set of brake pads is a lot cheaper than, you know, death.

All in all though, the torque vectoring system does an excellent job of both unleashing and taming the ST's wild side. You need to be here to drive though: the manual gets tiresome in city traffic, natch, and the open road always beckons.

Now it's just a matter of waiting impatiently for the even hotter 235 kW Focus RS... **LINDSAY HANDMER**







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# WHAT WILL YOU BE DOING THIS NATIONAL SCIENCE WEEK?



15-23 AUGUST 2015

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**The Setup**

# ARMOUR FOR ROAD WARRIORS

For all the fun it offers, cycling can be dangerous. Total deaths might be low, but measured as a percentage of fatalities matched to exposure to risk, cyclists come off second best. But it doesn't have to be that way. New road gear can help riders avoid injuries—and crashes—altogether. **BERNE BROUDY**



**SAFER  
CYCLING**

## 1 HELIOS HANDLEBAR

Helios has created handlebars—which are available in bullhorn, drop, and flat—with a built-in 500-lumen LED headlight and two taillights. The latter double as blinkers, which allows a rider to indicate a lane change or a turn without taking a hand off the bars. Using Bluetooth

Smart, the bars can connect to a smartphone, and rider-facing lights will pulse with turn-by-turn directions to keep eyes on the road, not a GPS device. During those long night hauls, the glow won't fade because the system's USB-rechargeable batteries run for up to 15 hours with lights on high.

## 2 SCOTT RC PROTEC

A typical Lycra riding suit might be sleek and lightweight, but it shreds in a crash—along with your flesh. With help from Swiss textile maker Schoeller, Scott developed high-strength, break-resistant carbon yarn. The material is woven into cycling jerseys and bibs

where they're most likely to tear—the shoulders and hips—and then coated with ceramic. The fabric feels like Lycra, but the ceramic coating helps it slide across the footpath, not stick to it, and the carbon prevents the fabric from tearing. Call it a cure for road-rash. Though it won't help you against a B-Double coming at 122 km/h...

# 2.8

Percentage of Canberra residents who cycle to work. Might have something to do with all the bike paths...

## 3 GIRO SYNTHE MIPS

Giro marries aerodynamics with advanced safety technology in its new helmet—and the lid still remains light enough for top racers. The company covered the side air vents with perforated plastic to eliminate drag and to force wind to stream past while maintaining

plenty of ventilation. Between the shell and the foam liner is the MIPS (multi-directional impact protection system) low-friction layer. In the event of a crash, the layer can slide on the head independently from the helmet's shell, which reduces rotational forces on the brain (and thus serious brain injury) caused by angled impacts.



# Parrot<sup>®</sup>

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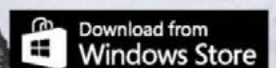
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# A CAR TO END TRAFFIC DEATHS



**Safety normally takes a back seat** to blistering performance when it comes to reporting on car tech. But Volvo's new XC90 SUV is so packed with life-saving technology, it's an exception. The car has a number of radar sensors and camera monitors used by its crash-avoidance software to keep passengers safe. If its computer system deems that a crash is imminent, it can alert the driver—or take control.

Short of turning the XC90 into a fully autonomous car, Volvo has used every driverless tool at its disposal. Radar-based cruise control keeps the vehicle a safe distance from traffic ahead. Cameras monitor traffic lines for automatic lane centring. If the car senses you're letting it drift, it vibrates the steering wheel. Radar scans your

blind spots, so if you attempt to merge into an occupied lane, an alarm sounds and lights in the side mirror flash.

A lot of that technology might sound familiar these days. But the XC90 takes automation a step further, into the realm of artificial intelligence. It has software that learns your driving style and, by monitoring your steering, braking, and acceleration patterns, can catch your mistakes before they turn deadly. The car compares your behaviour to previous drives. So, if you start jerking the wheel, the centre console will flash a text warning advising you to take a break. It's also the first SUV in the world to automatically brake if it's headed toward an oncoming car, cyclist, or pedestrian. The car does this with windscreen-mounted



## DESIGN OF THE MONTH

### CHEVROLET-FNR CONCEPT

It's the car we've dreamt of for decades: With driverless operation enabled by roof-mounted radar, electric motors in each wheel, and a wireless charging system, the Chevrolet-FNR is a sneak peek into the future of the four-door family sedan. The concept also has iris-scanning security that recognises the owner as well as front seats that swivel 180 degrees to face rear passengers.

radar that scans up to 200 metres ahead, night or day, rain or shine. If a collision is imminent, it will brake even if the driver has the accelerator flat to the floor.

All of these innovations make the XC90 SUV the crown jewel of Volvo's audacious in-house pledge to eradicate death and serious injury in all of its vehicles by 2020. As such, it even protects you against other drivers' recklessness. Rear-facing radar monitors the speed and distance of vehicles behind you. In the event that you're about to be rear-ended, the XC90 tightens your seatbelt and applies the brakes so you don't strike vehicles ahead. Volvo also rearranged the bulky seat-adjustment motors and other hardware beneath the seats, making room for self-crumpling frames that direct energy away from passengers. The system reduces the risk of spinal injury by 30 per cent.

Though it may not be the most powerful SUV out there, the XC90 has become a dominant force in highway safety. **ERIC ADAMS**



### VOLVO XC90

**Fuel Economy** 11 L/100km

**Acceleration** 0 to 100 in 6.1 sec.

**Horsepower** 235 kW at 5,700 rpm

**Price** starts at \$89,950

The XC90 is the first SUV in the world to automatically brake if it's headed toward an oncoming car.





# Free Your Wi-Fi

## PROBLEM

The number of Internet-connected devices in your home has exploded—iPhone, Sonos, Nest thermostat, app-controlled cat feeder. When they're all vying for Wi-Fi signal (or if your router's across the house), speed slows to a trickle. It's no wonder buffering keeps killing your *Orphan Black* marathon. "There's this last-inch problem," says engineer Nick Weaver. "We've got great pipes bringing faster Internet into our homes. But how do you get that speed to everything?"

## SOLUTION

Weaver helped develop a smarter router called Eero (Aussie price TBC). Each Eero communicates with one another, creating a mesh network of up to 10 units. It switches frequencies to overcome interference caused by neighbours' networks, and boosts the signal at each node to combat distance and walls. Each system supports hundreds of devices, so your smart home won't get in the way of your binge-watching. **LINDSEY KRATOCHWILL**



# 54

Estimated percentage of Internet protocol traffic wireless devices will use by 2016 according to the 2014 Cisco Visual Networking Index

**BYE-BYE  
BUFFERING**

## Coming Soon

## RISE OF THE (NEARLY) INVISIBLE WEARABLE

**Tattoos already say** a lot about a person. They're about to communicate a lot more. A new wave of ultrathin, flexible stick-on sensors are entering the wearables game, promising to improve our lives with (even more) data.

For now adhesive mini computers are mostly in the "look-how-cool-it-is" phase. Google released a digital tattoo last year that uses near-field communication (NFC) to unlock a Motorola Moto X smartphone. That's fun. But that's all it does. Other companies are jamming sensors and antennas into these nano-thin waterproof devices that could potentially save lives.



The wider promise of digital tattoos will come with health and fitness trackers. The SEEQ Mobile Cardiac Telemetry System, created by Medtronic, sticks onto a cardiac outpatient's chest and sends continuous heartbeat information to a medical monitoring service. The staff there can then analyse and send that data to a specialist.

MC10, a company that specialises in stretchable electronics, will release the BioStamp system, which tracks heart rate, body movement, temperature, and other biometric data so people can monitor their own health at home. These sensors will provide real-time information for days on end—meaning smartwatches and wristbands, new though they are, might soon be a thing of the past. **ANDREA SMITH**

# Is this the end of the plug-in vacuum?



**Dyson's new** V6 Absolute handstick vacuum cleaner is so powerful, it almost makes a bulky plug-in unit unnecessary. We say almost, because here in Australia we face a conundrum: plenty of us have enough disposable income to drop \$899 on a handheld vac, but we also have houses that are too big for the V6's 15-20 minute run time.

For a quick touch-up before the guests arrive though, the V6 is hard to fault. Dyson has redesigned the carpet head, with fewer bristles to prevent blockage, and a more powerful motor to spin the brush. Coupled with its latest generation of "digital motor" (a kind of brushless electric motor that's surprisingly powerful for its size), the V6 sucks more grit out of even the shaggiest pile.

The new element to the Absolute package is the hard floor tool. Dyson says most Aussie homes have tile, wood or other kinds of hard floors. With wall-to-wall carpeting out of vogue, a sophisticated hard floor tool will be well received. The result is an odd combo of vac head and clothes lint brush: a large-diameter cylinder covered with what looks like felt.

The results speak for themselves: the V6 can pick up impressively large chunks of filth (as long as they are mostly dry) including spilled cereal.

The V6 also includes a HEPA-grade filter for the first time. Yes, you have to clean it, but it ensures that nasties go into the vac and don't come back out.

**ANTHONY FORDHAM**



**DYSON V6 ABSOLUTE**

Price: \$899

[www.dyson.com.au](http://www.dyson.com.au)



**DYSON HUMIDIFIER**

UV steriliser

Patented "air multiplier"

Also works as a fan

Price: \$799

## WET THE AIR AND FEEL BETTER

**Every year** Dyson announces a new fan-related product. For 2015, it's this humidifier. These things are huge in Asia and parts of the US but it remains to be seen how Australia will embrace a device that pumps the local environment full of water vapour (especially in humid Sydney). However, in a high-rise office a humidifier is the device you didn't realise you needed. Individual results may vary, but upping the humidity could reduce headaches and other negatives associated with living at a dry 24 degrees for eight hours a day. Dyson's take integrates a UV steriliser in the reservoir and the familiar "air multiplier" to blow a stream of foggy funk into your face (this is a good thing). The unit can automatically sense air water content and adjust accordingly - typically we found it wanted to pump the wet stuff at 70%, implying our office is super-dry. That explains the eczema. Ew. **AF**

**120**

operating speed, in thousands of RPM, of the Dyson Digital Motor used in the V6 vacuum.

## WHEREFORE THE EYEBALL?

**It seems** like a year ago Dyson announced its take on the robot vacuum cleaner with the 360 Eye... because it was. Tank treads, camera, super-smarts, this robo-vac will have it all. So where is it? The answer, according to Dyson's rep, is that the device is still "in Beta". Could this be the boondoggle that breaks Dyson's back? Unlikely: robot vacs are massively popular, and one that can actually see could spur the segment to even greater heights. **AF**





# The Foundation for the Advancement of Astronomy supporting excellence

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# STEWART BUTTERFIELD WANTS TO KILL THE WATERCOOLER

EDITED AND CONDENSED BY MICHAEL NUÑEZ



**As useful** as it once was, email has become a hodgepodge of unorganised conversations. Add to that other tools—Twitter, Google Hangouts—that crowd our screens. Slack, an app that's conquering cubicles worldwide, stacks nearly all of your communications in one place. You can share files, direct-message, and search a project's entire history. So where is all of this communication headed? We asked Slack's co-founder, Stewart Butterfield.





**The Platform**

**Popular Science:** Let's not mess around: is email on its deathbed?

**Stewart Butterfield:** Email isn't going anywhere, but it's the lowest common denominator of communication. For one, every message is treated equally: family, work, friends, bank statements, and newsletters. They're hard to sort through. You also have this very tiny window into a conversation. With Slack, you can view a whole conversation thread—even before you join it. That means that there's a huge increase in transparency.

**PS:** So are you trying to kill all the other communication apps?

**SB:** No. The company's mission is to make people's working lives simpler and more productive. One way you can do that is to reduce the overhead of constantly switching between programs. There is now one place where they all come together. So it's not that we want to eliminate people's use of those services—we don't. We want to make it easier for them to



urgent, they can override it. We're trying to build in tools that default to respecting people's time. People can concentrate when they want to. They can sleep their notifications for half an hour when they're in the middle of thinking deeply about something or if they're in a meeting.

**PS:** What happens if you want to ignore someone indefinitely?

**SB:** That's kind of a social problem,

**“We’re already at the point where people sign into dozens of services each day just to get their work done.”**

use those services. And one of the ways we make it easier is by having everything come together in Slack.

**PS:** Don't people resent this constant connection to work?


**SB:** It's definitely something we think about quite a bit. Recently a European tweeted, saying Slack is exporting the worst aspects of American culture, where people work all the time. But he was really asking for a feature to make it easier for people to manage their time better, and that's something we're working on.

**PS:** How so?

**SB:** For example, we are working on a “do not disturb” mode that kicks in by default and adjusts to your time zone. If someone sends you a message during that time, they'll be told that you're in do-not-disturb mode. If it's

that should be solved between employees. Although I think it is much easier to skip over someone's message when you see it's from them—to skip over it with your eyes—than to stop listening for 45 seconds while they speak it out loud. So it should be an improvement.

**PS:** Why has messaging become the killer app for big companies?

**SB:** Messaging is a fundamental social activity. If you're not using an app, you're uttering something with your mouth. And someone is listening with his ears. And when you stop talking, the message is over. It's the same form of conversation that has been around since the dawn of language. It's what two or more human beings do with one another. If you're having any kind of interaction, it's really just messaging. 

# GRAPHICS TECH MEANS PC IS STILL KING

**Graphics processing unit** (or GPU) manufacturer NVIDIA has spent the last decade continuously pushing the envelope when it comes to gaming visuals. This year, new chip architecture and a new graphics standard called DirectX 12 will take eye candy to new levels.

Gamers who upgrade their top-end PCs with a GeForce GTX 980 Ti videocard (sold by various manufacturers, but starts at around \$1000) will be able to play games at 4K resolution, see realistic smoke and fire, better shadow and light, and will

## CURVED (EYE)BALLS

VR headgear sends a slightly different image to each eye, creating a 3D effect. But the actual "screen" in the goggle is mere millimetres from your face, and the curve in a human eyeball causes distortion at that range. Programmers compensate by having the computer render a distorted image, which is then "straightened out" by the lenses in the VR goggles for a perfect view. Until now, this process has been wasteful, as the game renders pixels that won't appear in the goggles. NVIDIA's latest tech recognises this and dynamically drops pixels to reduce workload on the GPU and speed up performance.

be ready to plug in a virtual reality headset sometime in early 2016.

Most gamers who spend this kind of money will have a 4K display or at 2560 x 1440 monitor at the very least. Compare that to a console's typical "almost full HD" resolution of 900p (some games do run at 1080p though). But it's not just about the pixels - games on PC can draw on the processing power of the CPU and GPU to make objects in the game world interact more realistically, be it something simple like falling rocks, or more complex like the wind from Batman's batarang dynamically pushing fog aside and creating vortices, like it would in an overly-dramatic Christopher Nolan movie. Speaking of Batman, he's all about the shadows, which is why NVIDIA's new tech uses a "conservative raster" to create pixel-perfect shadows for game objects - instead of the weirdly "blurry" shadows you'll see in console games.

Because PC gamers have big screens, NVIDIA designed the GTX 980 Ti to increase performance more dramatically at higher resolutions. Combine all this with a "G-Sync" monitor that dynamically changes its refresh rate to match the game's framerate, and you're looking at a gaming experience that's not so much inching toward photorealism as charging ahead. Possibly on the back of a dinosaur. **ANTHONY FORDHAM.**

IT BRINGS  
THE BAT

**GTX 980Ti**



By stacking memory on top of memory, Samsung can pack more space into this tiny drive. It's much faster than a regular HDD, but more expensive too.



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 9.2 x 71 x 53 mm  
 250GB \$269  
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## A PORTABLE DRIVE THAT'S HUGE AND TINY AT THE SAME TIME



**Remember life without** high-capacity portable storage? Shudder. Even so, until now you've had to choose between a pack-of-cards sized hard drive with terabytes of storage, and a super-teeny USB stick with mere gigabytes. The USB stick transfers files with lightning speed, while the HDD is slower. We want the best of both worlds: a high-capacity solid-state drive that uses an ultra-fast USB 3.0 connection. And here's an early contender: Samsung's first portable solid-state drive.

Called the T1, it's small, yet fast. Like 425 MB/s read and 412 MB/s write fast.

So how does Samsung do it? The T1 is based on Samsung's existing 850 EVO SSD and uses V-NAND memory chips. This is an innovation that lets the manufacturer stack memory

cells on top of each other, rather than building them as a flat array. A simple analogy is a suburb - with just houses, you can only have so many people. Chuck in a few blocks of flats, and you can fit more people. What Samsung has done is build high rise towers, Hong Kong style.

The upshot is more storage in the same space, while also being faster and more robust. Longevity is actually very important and SSDs wear out over time. The Samsung V-NAND tech means your portable drive will last a lot longer - so much in fact that the



typical short lifespan of flash memory is no longer an issue. The T1 also uses a fully-fledged SSD controller, like in a PC, to ensure top notch read and write speeds.

The T1 does have a few quirks and is not exactly cheap. While light and small, it still needs a cable to plug into your computer. And it uses a trad micro USB 3.0 connector, not the newer, slimmer USB Type-C as found on the latest MacBook. Capacity is good though: you can get the T1 in 250GB, 500GB and 1TB versions.

**LINDSAY HANDMER**



### **WD MYPASSPORT ULTRA**

Available in sizes up to 2TB, the Ultra uses USB 3.0 but speed is limited by its mechanical/magnetic format. Considering the capacity though, it's quite cheap at \$149.

[www.wdc.com](http://www.wdc.com)



### **SANDISK EXTREME PRO USB 3.0**

Ultra-portable, this flash drive manages over 200 MB/s read and write speeds but only has a 128GB capacity. So you're paying for speed, not space. \$150

[www.sandisk.com.au](http://www.sandisk.com.au)



### **SILICON POWER X20 OTG**

This little USB drive can be connected to both your computer and your phone, thanks to a Micro USB plug. Even better, a generous 32GB costs just \$30.

[www.silicon-power.com](http://www.silicon-power.com)

COMPUTEX 2015

# The IT Show to End all IT Shows

↓

**Every year** manufacturers launch a huge range of new products at the Taiwanese trade show we know as Computex. From important stuff like new platforms or CPU line-ups, all the way down to a USB drive in the shape of a little dog who looks like he's humping your PC, Computex has it all. Here then are a selection of 2015's newest IT gadgets, from the sublime to the ridiculous. **LINDSAY HANDMER**

## 1. MSI GT72 Dominator Pro

Not only does this new version of MSI's laptop excel at gaming, it adds eye tracking thanks to Tobii Tech. No more scrolling about - the laptop and games will simply follow where the user looks. The GT72 also packs the latest Intel Core i7-5700HQ CPU, for serious grunt.

## 2. G-Sync

NVIDIA's G-Sync technology gives a smooth, tear-free gaming experience on desktop monitors, but until now laptops had been left out of the loop. No more! We tried it - the system works. Of course AMD also has a competing technology, called FreeSync.

## 3. ASUS ROG G20CB

A mini PC like no other, the ASUS G20CB features Intel's new Skylake technology. The sleek case squeezes in a high end graphics chip as well as a quartet of solid state drives. It also has customisable LEDs that can display eight million colours. Because you need that many.

## 4. Alienware Area 51

Another year, another stonking PC from Alienware. Personal taste determines whether you think the look is kitsch or cool, but this is still the most over-the-top package PC money can buy. It starts at \$2999, but if it's specced up with extra GPUs, SSDs and RAM the price can quickly breach \$5000.

## 5. Smanos K1 SmartHome

A DIY kit that can connect and control up to 50 different wireless accessories, the K1 helps make a smart home, well, smart. It also won the Red Dot design award for simplifying home automation - something this segment needs, very badly.

## 6. Dell Ultrasharp 34

Dell's monitors are already some of the best, but now the company adds a massive 34" curved display. With cinema-like 21:9 aspect ratio, IPS panel and 3440 x 1440 resolution. Of course it does cost a hefty \$1300.

## 7. AMD Carrizo

Launching a new laptop APU, AMD has promised to improve performance and double battery life. It's aimed at lower end laptops too, providing serious gaming and number crunching performance on the go. And hopefully at a reasonable price.





**8. ODin Aurora**

Originally funded through a Kick-Starter campaign, the ODin Aurora is a projection mouse. It may look like a transformer, but it tracks a finger's movements with a laser to replicate a touchpad on any surface. But why does it have that ridiculous face?

**9. ASWY Air Speaker**

The problem with your current speaker is it doesn't levitate. Using magnets, the Air Speaker floats a driver above the base for one-of-a-kind sound. It can stream music via Bluetooth or plug in with a 3.5mm cable. Gimick or future of HiFi? Answers to the usual address!

**10. Roccat Nyth**

Innovation in the saturated gaming mouse market is hard (see ODin's silly face), but Roccat has done it with the fully customisable Nyth. Users can literally build the mouse exactly how they want it, by adding or removing various buttons and body panels.

**11. Thunderbolt USB Type-C**

Intel's Thunderbolt transport format is incredibly fast, but beyond Apple, the custom connector isn't found on many devices. Intel has now adopted the USB Type-C standard and has made the technology backwards compatible with USB. Lightning will strike twice! (Or something.)

**12. Intel Wireless Charging**

Charging without wires is great, but devices have to sit right on the pad, making it barely more convenient than plugging in. Intel has stepped up with a new system that allows people to charge laptops, tablets and phone anywhere on a table.

**13. Lennox TB120 Tablet**

A weird yet appealing throw-back, the TB 120 is an ultra-tough tablet designed for rough and tumble outdoor use. It stands out thanks to the inclusion of an actual physical keyboard, but only runs Android 4.1.1.

**14. Intel CPU Upgrades**

With 6th Generation Skylake CPUs due, Intel has given the 5th Gen Broadwell chips a boost too, as well as rolled out a number of new options. They are expected to be available in the next two months. The practical result for you? Hang off buying a new notebook until later in the year - you'll get more bang for your buck.

**Form Factor**

# A WIRELESS SECURITY CAMERA THAT ANYONE CAN HANDLE



**Setting up** a networked camera based security and monitoring system in your home can be complex, frustrating experience. So Netgear built Arlo - a smart, simple system that ditches the wires.

By "Arlo", Netgear means an entire system of base station and up to 15 smart cameras. Everything is battery operated and totally wireless. The camera looks like something from a 1970s SF movie and have just a single button to sync. Each unit is fully waterproof and has onboard motion-detection and night vision. Range is 90 metres, and we had no trouble with reception in a typical house. Each camera runs on four CR123 batteries, which Netgear claims last about six months.

Mounting the cameras is dead easy. Along with a tripod screw mount, each unit has a powerful magnet on the rear. You don't have to attach it to metal either - they come with a mounting pad. This makes it simple to move the camera or swap batteries.

Slap a camera into place, plug the base station into your router and run the app on your phone, or log in via a web page. That's it.

You can activate specific cameras to record video or take pictures, or just let them choose when to activate via motion sensing. The 720p video quality is quite good, and the app is excellent and lets you fully control the cameras, schedule sleep and wake times, tweak motion activation, or download recorded videos.

The biggest drawback is that the cameras don't record audio. So while they are great for security and monitoring, or even keeping an eye on your pets, they don't work as, say, a baby monitor.

The system automatically stores recordings for seven days online, but longer backup requires a monthly fee.

Arlo will set you back \$349 for a base station and one camera, \$589 for two cameras, and \$799 for three cameras. You can also get the cameras separately for \$249 each.

**LINDSAY HANDMER**



**NETGEAR ARLO**

**Price:** From \$349

**Resolution:** 720P

**Battery:** 4x CR123

**Battery Life:** 6 months

**Range:** 90 metres.

**Connection:** Wireless

[www.arlo.com](http://www.arlo.com)



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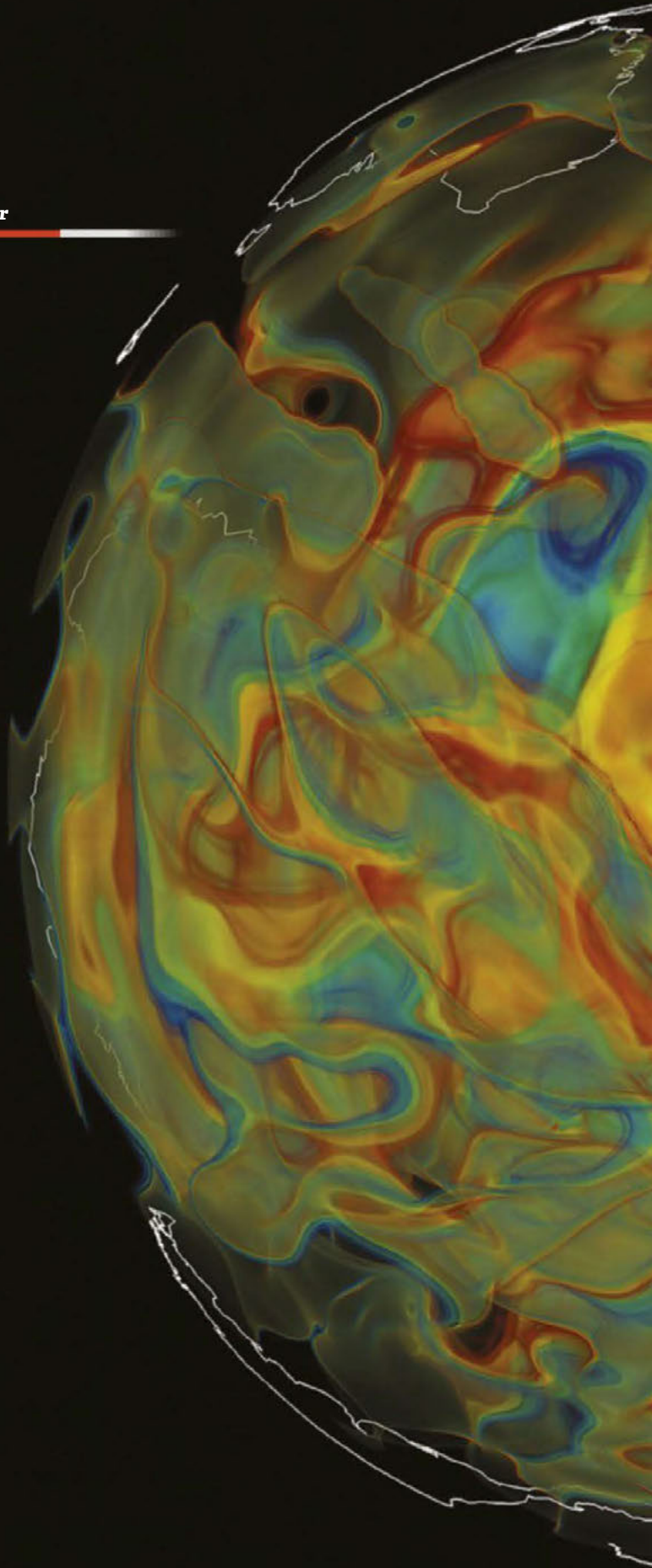
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## Earth's beauty is more than skin-deep



**Inner Earth** is a mysterious place. Its seismic rumblings spawn deadly earthquakes and volcanoes, often without warning. But a new model, powered by Oak Ridge National Laboratory's Titan supercomputer, analyses reams of seismic-wave data to reveal the contents (and potential behaviour) of Earth's mantle in strikingly clear detail. Blue and green swirls represent cold, dense rock, through which seismic waves move quickly. Red and orange indicate hotter, younger rock that slows waves down. Seismologists can use the 3D model to pinpoint hidden magma pockets or underlying tectonic plates. Someday it could also change the way engineers prepare for earthquakes. "Suppose you want to build a structure in Los Angeles," says Princeton University geophysicist Jeroen Tromp. "We can precisely simulate the kind of ground motions it might be subjected to and make informed decisions about building materials." RACHEL FOBAR







# 250

Number of  
earthquakes,  
magnitude  
5.5 and greater,  
analysed to  
make this  
3D model

Do you picture an ocean of molten lava - or magma - beneath the crust? In fact, the mantle is solid, but in a "plastic" state where the rock flows over thousands of years in great convective currents. Magma is found in relatively small pockets and cracks throughout the mantle, where specific conditions cause rock to melt.

# THE FOUR-DIMENSIONAL FUTURE OF STUFF

Ours is a world of static objects, cut, cast, or forged for specific tasks. But let's say you opened an Ikea box, and the desk inside assembled itself. Or your water pipes shrank as the pressure decreased: no more weak showers, less wasted water. This is the 4D-printed future, and labs are already striving to make it a reality.

The tech builds on 3D printing—with the added fourth dimension of time, across which objects transform. Skylar Tibbits, founder of MIT's Self-Assembly Lab, coined the term "4D printing" in a 2013 TED Talk and showed how a straight plastic strand folded into the letters *M*, *I*, *T* when dropped in water.

The emerging research area is a sexy subset within the larger field of programmable matter, which also includes North Carolina State's self-folding origami polymers and Harvard's self-assembling robots. Whether 4D-printed or not, programmable matter morphs in response to a contextual cue, be it light, heat, water, air pressure, electricity, or magnetic fields.

Funding from DARPA and the Army Research Lab has accelerated the work in the past two years. Engineers are now working toward self-assembling pop-up bridges, uniforms that adjust their insulation to individual biometrics, and camouflage that changes to match its surroundings. "It teases the imagination," says Jennifer Lewis, professor of biologically inspired engineering at Harvard. "But a lot more work has yet to be done to see where the real killer application is going to come."

Meanwhile, the MIT lab focuses on everyday applications of 4D printing. "Our strategy has been to collaborate with companies to get this into the hands of real-world people," Tibbits says. Last year, his team printed various materials onto a sheet of carbon fibre that, when exposed to heat, curled into a predetermined shape. The tech soon may enable

# 4

Minutes it took  
a 4D-printed  
carbon sheet to  
fold itself into  
a walking robot  
at Harvard

extra-aerodynamic car spoilers and aeroplane wings.

"It changes the way products can be designed," says Junus Khan, founder of advanced-materials company Carbitex, which partners with the MIT team. "With materials that ship flat and undergo a shape change at the other end, we can consolidate 10 containers into two."

Programmable 4D-printed materials will need safety measures baked in so bridges don't spontaneously disassemble and airplane wings don't freeze in the wrong position. But that doesn't deter Tibbits' group at MIT. "Our goal and our mandate," he says, "is to invent the future." **MEGAN MOLTENI**

**"The vision is to print smart materials that can transform themselves. Like robots but without all the wires, sensors, and motors."**

—SKYLAR TIBBITS, MIT research scientist





# A tabletop boardgame... that's also a videogame



**Seattle-based** games company Harebrained Schemes makes most of its money from videogames. But thanks to the passions and peculiarities of CEO Jordan Weisman, the company still creates physical, tabletop games. "There's a kind of social interaction you get gathered around a table that a videogame just can't replicate," he says.

Of course, the up side of a videogame is that the program can

## 1990

**Year the first BattleTech Centre opened in Chicago. A virtual-reality arcade game with full enclosed cockpit, joysticks, pedals etc. Invented by Jordan Weisman.**

take care of all that fiddly record keeping, calculation and of course any last-minute changes to the rules.

Which is why one of Weisman's latest creations - Golem Arcana - combines what he says is the best of both worlds. The tactility of tabletop and the convenience and cleverness of digital.

Golem Arcana is a squad-based tactical battle game, where players select an army of creatures and fight on a battlefield made up of various tiles. It's more Chess (with lots of extra rules) than Monopoly.

Traditionally, games like this come with a thick rulebook, and as the game unfolds, players must constantly reference look-up-tables

tricky rules, giving players a simple result for each round of combat. The app even includes virtual dice - though you can roll real dice too if you're worried about the true randomness of the digital system.

The app "knows" the layout of the board and armies, thanks to a gadget of Weisman's own invention. It's a chunky stylus equipped with a Bluetooth transmitter and a sensitive infrared camera.

"The Tabletop Digital Interface, or TDI stylus, reads tiny IR dots on the base of each miniature," Weisman says. Tap a unit then tap a location on the board. The human moves the miniature, the app moves a digital representation. "There's no manual entry of information. The app handles all the math."

That's the basics, but with the digital element to the game, Golem Arcana can be so much more than just a few pieces on a board.

"When you play a game of Golem Arcana, the results are uploaded to our servers," Weisman says. "We track every single game that gets uploaded, and that means we can continually tweak balance and even change rules if necessary." And instead of downloading a PDF of errata, players just play - the app handles all the changes.

What's more, there's an optional

global campaign to play along with. The results of each campaign match are uploaded, and the outcome of individual battles can change the overall story.

"Because it's a tabletop game, we're talking thousands of players instead of millions," Weisman says. "So your actions in the campaign can

really have an effect."

Sales of the game have so far been "good but not amazing", and you can pick up a copy at most dedicated boardgame stores. The base set comes with a bunch of miniatures, and extras can be purchased as expansions. **ANTHONY FORDHAM**

## NOT LORD OF THE RINGS?

**Many new tabletop** games license an existing IP to generate a bit more interest - the Star Wars X-Wing Miniatures game is just one example. So why didn't Weisman license something instead of creating a whole new world for Golem Arcana? "When you have something really innovative, like the stylus, you don't need someone else's IP. This is the right time to introduce a new story."

and check esoteric cases like "what if my guy is on sand but your guy is on a hill, but my guy gets a bonus for sand but your guy has an elevation advantage." Golem Arcana gets around this with a companion app.

Running on smartphone or tablet, the app handles all "modifiers" and



# A WIND MACHINE YOU CAN CALL HOME



**Windmills have dotted** the Dutch countryside for centuries. But in densely populated cities, whooshing turbines are a tough sell. A new concept called the Dutch Windwheel could offer a silent, low-maintenance alternative.

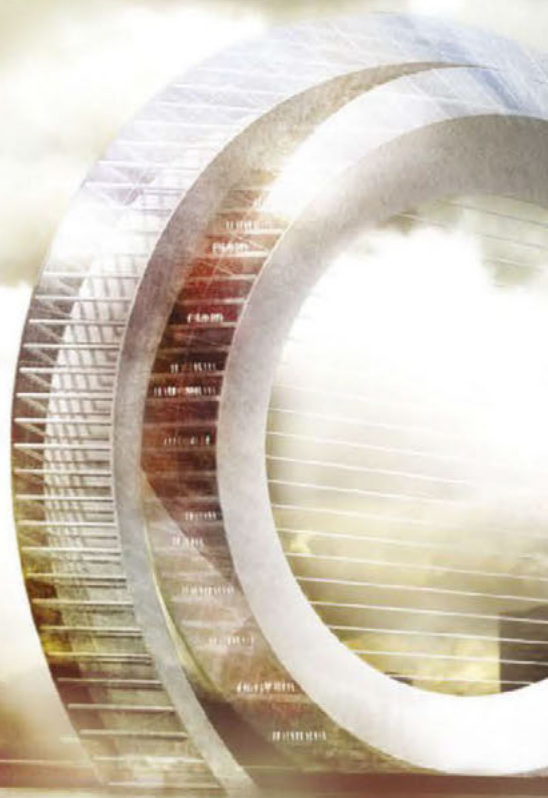
While most turbines use spinning blades to turn the kinetic energy of wind into mechanical energy that generates power, the Windwheel cuts out the middle step. Its electrostatic wind-energy converter uses wind, water, and an electric field to directly produce a current.

So far, the tabletop prototype produces just 12.5

milliwatts—not enough to power a light bulb. And it's only three per cent efficient, compared with a typical wind turbine's 45 per cent efficiency. But if the technology advances on schedule, its creators say a 175-m version could grace the Rotterdam skyline by the early 2020s.

People will be able to live, work, and dine inside the self-powered skyscraper as it cranks out a megawatt of electricity. "We wanted a 100-per-cent-sustainable building that serves as a platform for all kinds of innovations," says developer Lennart Graaff. **MARY BETH GRIGGS**

Sections of the glass facade will include augmented-reality touchscreens, adding a virtual layer of information to the panoramic views.





## INNER RING

The building's design consists of two concentric rings atop an underwater foundation. The inner ring will be constructed of a steel frame and a glass exterior, which will provide sweeping views of the city for a restaurant, a seven-storey hotel, 72 apartments, and office space located within.

## OUTER RING

The outer ring will function as a massive Ferris Wheel, like the London Eye. Its 40 glass cabins will take passengers above the city's world-famous architecture and below the surface of the canal.

## PUMPS

The Windwheel will pump water directly out of the canal for use in its electrostatic wind-energy converter. The system can also operate using seawater or collected rainwater.

## ELECTRO SPRAYERS

Horizontal beams will stretch across the centre of the Windwheel. Thousands of nozzles located along them will spray positively charged water molecules into the air. When wind pushes the droplets against the beams' high-voltage electric field, it will create a negative charge.

# 10

Anticipated  
number of  
years it will  
take the Dutch  
Windwheel to  
pay for itself

## CHARGING SYSTEM

The negative charge will form a current as the electricity discharges, much like when the negative charge that builds up in thunderclouds discharges to the ground via lightning strike. The electricity will then be converted from direct current (DC) to alternating current (AC) for use in the Windwheel or storage in an industrial battery.

## LIGHT AND HEAT

Solar panels on the outside of the rings will generate additional energy. To warm the building, a so-called regional heat roundabout can deliver excess industrial heat from Rotterdam's port—the largest in Europe—through a network of pipes.

# Temple Grandin

On how to raise resilient animals

**In the 1990s**, animal scientist and autism advocate Temple Grandin revamped the livestock industry to improve animal welfare and food safety—which meant lower costs too. Today, almost half of the cattle in North America is processed through a system she designed. Now, she's focused on a new challenge: how to reverse the damage done by decades of overly selective breeding.

“When it comes to breeding animals today, many factors contribute to what I call “biological system overload.” People are over-selecting animals until they get health problems. Hens, for example, are chosen for greater egg production and end up with osteoporosis. They put all their calcium in the eggs and there's nothing left for their bones. Recent studies on pigs and other animals indicate that high-producing animals may have less resistance to disease. We're seeing the consequences of that now.

It's possible the current avian flu outbreak [in the US] might be related to genetics. A study presented at the Midwest Poultry Federation Convention showed that wild ducks can live with avian influenza, while it kills high percentages of domesticated turkeys.

So let's breed some hardiness back into these animals. Let's have a little less milk, and then we'll have a healthy cow that will milk for four years instead of dying after two. We need to breed for optimum—not maximum—production.

Another problem we need to address is that people are too far removed from the entire world of practical things, including farming. That can result in people making policy about stuff they don't know anything about. Take lab-grown meat, for example. It's a nice idea, but it's not very energy efficient. A warm-blooded animal requires a lot of energy. If you want to grow food in the lab, why not grow scallops without the shells? We've got to get people connected to real, physical stuff—it teaches problem solving.”

AS TOLD TO LOIS PARSHLEY

## 41

Chickens, in millions, infected with avian influenza between December 2014 and June 2015. The USDA says it's the worst US outbreak ever.

“I think a lot of millennials feel a disconnect—they want to know where their food comes from, but a third of them have never been on a farm.”



# MOSQUITOES DESIGNED TO SELF-DESTRUCT

Red denotes the US counties in which the invasive *Aedes aegypti* mosquito has been detected at some point, but it has likely gone unreported in many others.



Every year, mosquitoes infect 400 million people with dengue fever, causing severe headaches and joint pain. Since a 2009 outbreak in Key West, the Florida Keys Mosquito Control District has spent \$1 million a year to try to curb the primary vector: *Aedes aegypti*. Last July, another mosquito-borne virus reached US shores: chikungunya. Now officials are considering a radical—and highly controversial—approach to control the spread of tropical disease: genetically-modified mosquitoes.



**“I think this is one of the greatest ideas in the history of pest control.”**

—Rebecca Trout Fryxell, entomologist at the University of Tennessee

The modified mosquitoes, code-named OX315A, eliminate more than 90 out of every 100 wild mosquitoes.

**5**

Oxitec is planning trials for the Keys this year, pending approval from the FDA and a local board. Concerned residents are lobbying to block them, fearing potential unforeseen consequences of releasing the genetically-altered insects into the environment.

**6**

Dengue's not all. “The chikungunya virus can mutate and is permanently established in the Americas,” says Stephen Higgs, director of the Biosecurity Research Institute at Kansas State University. More than 2,300 travellers brought the disease to the United States in 2014, and Florida counts 11 locally transmitted cases. “We don't know what it'll do next, but it could become widely distributed in the US,” Higgs says.

**7**

Wiping out the mosquitoes isn't a perfect solution, though. “Even if it is effective, this technique has shown it can reduce mosquito populations, not disease,” says Durland Fish, an epidemiologist at Yale University. These viruses can be wily. “It is not one and done.” **MATT GILES**

**1**

The *Aedes aegypti* mosquito thrives in urban settings and is highly resistant to insecticide. Plus it almost exclusively bites humans. “It has successfully spread around the world on human transport,” says Andy McKemey of insect-control company Oxitec. “It is the rat of the insect world.”

**2**

To keep populations in check, Oxitec genetically modified the insects. They injected mosquito eggs with synthetic DNA that codes for a self-limiting gene. This doesn't kill the mosquitoes outright, but it prevents their offspring from reaching adulthood to mate.

**3**

“We release sufficient numbers of males to out-compete locals,” McKemey says, “and that gene is passed to their progeny.” Then additional releases of modified mosquitoes ensure that the wild populations are diminished enough to no longer pose a threat.

**4**

Oxitec has conducted trials with its modified mosquito in dengue-ridden regions of Panama, Brazil, Malaysia, and the Cayman Islands. The results show population suppression rates above 90 per cent—far greater than the typical 30 per cent achieved with insecticides.

**5,000**

Rough number of modified *Aedes aegypti* mosquitoes released per resident during Oxitec's 2014 Panama trial

## WE SEE YOUR PAIN

A new imaging technique could help end the mystery—and the stigma—of chronic pain



**Nothing hurts** Westerners more than chronic pain. It's our single biggest health problem, affecting the lives of 100 million adults—more than heart disease, cancer, and diabetes combined. And that figure, from a 2011 Institute of Medicine report, doesn't even count kids in pain, veterans with devastating war injuries, or people in nursing homes.

Yet despite the fact that chronic pain is the primary reason many receive disability benefits, it's one of the least understood afflictions. Doctors are taught little about it, spending a median of nine hours on the topic over four years. Governments put absurdly few dollars toward research: \$4 a year for every person in pain versus \$2,562 for every person with HIV/AIDS. One big reason for the lack of resources is that there's no objective way to confirm that pain exists.

**The technique promises a better way to prove the existence of chronic pain.**

The good news, finally, is that scientists from Massachusetts General Hospital (MGH) in Boston have unveiled a new brain-scanning method that allows doctors to see chronic pain in exquisite detail for the first time. The technique, a merger of PET (positron emission tomography) and MRI (magnetic resonance imaging), clearly identifies that a patient is hurting, and offers a significantly better way to diagnose chronic pain. In trials, patients' scans lit up in brain areas corresponding to where in the body they ached.

The new method produced

# 44

Number of Americans who die every day from overdosing on prescription painkillers, according to the Centres for Disease Control and Prevention

dramatic images showing how glial cells—which are derived from the immune system but live in the nervous system—get activated in chronic-pain patients, ramping up the transmission of pain signals to the brain. “Over the past few years, we’ve seen this in animal studies,” says Marco Loggia, who led the MGH team. “But this is the first time we have proof that it works the same way in humans, and it’s a big step forward.”

The magnitude of these findings extends beyond the science. Many patients with chronic pain are mistakenly viewed by clinicians and

society at large as drug seekers or hypochondriacs. Without a blood test or biomarkers for pain, they fight skeptics and suffer through trial-and-error treatments. This visible validation that patients’ pain is real will go a long way to ease the stigma.

But it’s only a start. Now that we can see the activation of chronic pain, pharmaceutical companies should be aggressive with clinical trials to pursue new and novel treatments. “Pain can be reversed,” says Loggia. “In five to 10 years, we could potentially have a pill to do just that.”

JUDY FOREMAN







Anthony Fordham is the editor of *Australian Popular Science*. His cupboards are full of old music players and his floors are very dirty.

# Are we wasting our potential with gadgets?

COLUMN BY ANTHONY FORDHAM

**E**very year, Dyson sends a couple of representatives to the Popular Science offices to demo the latest generation of vacuum cleaner and whatever fan-related thing the company is doing that year.

And sure enough, each year the vacuum is more impressive. More powerful, better at doing its job, and with a more outrageous metallic plastic casing that somehow manages to look good. And the second product, whatever it is (this year it's a humidifier, see page 20) is always a beautifully designed rethink of something the world already has. Seriously - we've had fans, heaters, hand driers and more.

Yet every time I see another fabulously designed and expertly assembled Dyson product, and gotten over the shock of its price tag, I find myself wondering: Couldn't all this amazing human ingenuity be put to a more, you know, noble cause?

Yes, clean floors are what separates us from the animals, and I realise that Dyson is a business. But the company builds super-compact, super-powerful reluctance motors that can take a kicking. I actually asked the Dyson rep this time: why not apply this technology to, say, water pumps in the developing world? His response was to point out the Dyson Awards, an annual competition, not run for profit, that recognises impressive industrial design at a university level. Yeah. Not quite.

I don't want to pick on Dyson exclusively, others are guilty of the same thing. Apple has pioneered amazing construction techniques, even pioneered new kinds of metallurgy, and used it for glamorous computers and mobile phones. But at least Apple has the excuse of saying it would be HARD to apply mobile phone tech to saving the world, and anyway

**1000 YEARS FROM NOW, PEOPLE ARE GOING TO LOOK AT US IN THE SAME WAY WE LOOK AT THE ROMAN EMPIRE'S STEAM-POWERED TOYS**

the company is part of a global industry that improves communication. So there's that.

Dyson just seems to stick out as a company that has the tools, has the talent, spends some massive percentage of its revenue on more R&D... and yet still only builds vacuum cleaners. And fans, mustn't forget the fans.


Many Sci-Fi authors writing in the 1980s and 1990s predicted a world where big problems like food, health, freedom, security etc would continue to seem intractable, while our obsession with gadgets led to incredibly sophisticated personal tech. You might be starving, but you'll have a kickarse mobile phone.

The only difference between those visions and our reality is that the mobile phones are probably even more awesome than those 1980s writers imagined.

Yes, reinventing agriculture or creating safe nanotech that works or colonising another planet (to give the world's billions of systemically poor something to do) are all much, much harder problems than increasing a vacuum cleaner's suction by 30%. But is that really an excuse?

I believe we're reaching a point where, 1000 years from now, people are going to look at us in the same way we look at the Roman Empire's steam-powered toys. Rome had the knowledge and the workforce to create an industrial revolution... but they were too busy messing around (and okay, getting stomped by barbarians) to apply themselves.

You might say that Europe needed the horror of the Dark Ages to energeise the Renaissance. Fine. But we have the benefit of hindsight. We KNOW human ingenuity kicks into overdrive in times of crisis, so why don't we just engage the overdrive now, and avoid the crisis altogether? Progress, without all that death?

I guess I should take some comfort from the fact that no matter what happens, at least until the very end, we'll have clean floors. 


**7000**

Cost, in US dollars, of installing a typical well in Malawi. The same price as 11.6 Dyson V6 Absolute handstick vacuums. Source: Water Wells for Africa / Dyson



# HYPED UP





ELON MUSK PROPOSED A RIDICULOUSLY AUDACIOUS FORM  
OF TRANSPORTATION. NOW, STARTUPS ARE RACING TO  
BRING THE HYPERLOOP TO LIFE.

by **James Vlahos**

ILLUSTRATION BY TAVIS COBURN

# MAYBE

it was the Guns N' Roses pumping from the speakers. Or maybe it was the spell of

Dubai itself, a newly minted megalopolis whose explosion from the Arabian sands screamed that the past was dead and the future had arrived. Whatever it was, when Dirk Ahlborn launched into his speech at the Middle East Rail conference in March, he basically gave the roomful of executives the finger. "There hasn't been any real innovation in the rail industry for—I don't know how long," he said. "Either disrupt yourself or you are going to be disrupted."



The hyperloop concept isn't just a fantasy, says-Hyperloop Transportation Technologies' founder Dirk-Ahlborn, shown here near the Dubai Metro. "It's not like we want to invent an antigravity device."

The audience sitting attentively in the convention hall included men in traditional dishdashas and women in black abayas. Other attendees wore suits and ties or even heels and short skirts. Together they formed the industry's elite, people who built trains and ran railways around the world, while Ahlborn was the CEO of a startup, Hyperloop Transportation Technologies (HTT), that hadn't carried a single passenger or laid a single metre of track.

But restraint doesn't come naturally to Ahlborn, who wore, beneath his black suit, a white shirt open several buttons from the collar. Tall, with thinning brown hair and ruddy cheeks, Ahlborn began to pace the stage, TED-talk style, as he explained his vision for the future of transportation. "What is the hyperloop?" he asked. "It is a capsule, full of people, in a tube, elevated on

pylons, going really fast. It's that simple."

Hyperloop capsules would use either a magnetic field or a continuous blast of compressed air to float above the bottom of the tube. Pumps would remove most of the tube's air, creating an extremely low-pressure environment. Minimal air means minimal friction, so the capsules would travel at up to 1200 km per hour, powered entirely by solar panels. "How would your life be if you could travel 600 kilometres in half an hour, with a ticket price of \$30?" Ahlborn asked. "If we achieve that, we really change the way we live."

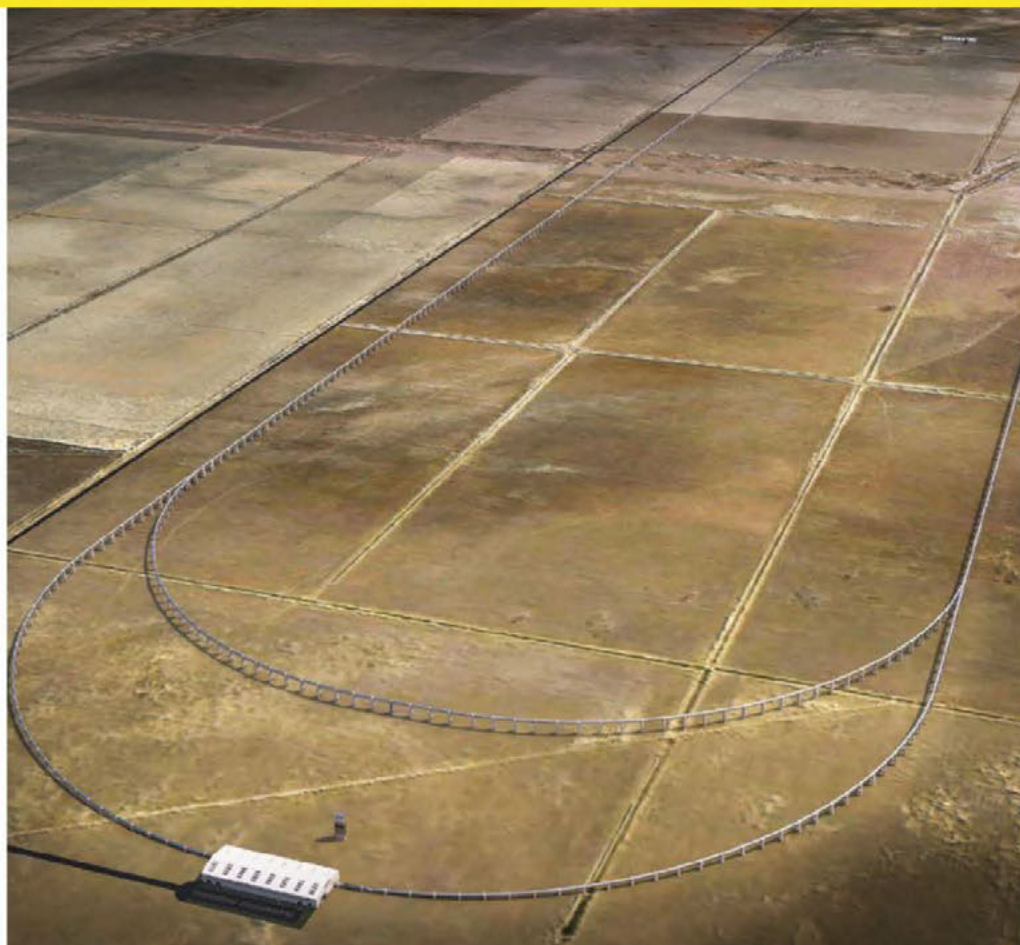
Ah, the hyperloop—the same scheme that Elon Musk, the CEO of SpaceX and Tesla Motors, famously proposed in a white paper back in August 2013. The pronouncement incinerated the Internet, with some awe and lots of *are-you-kidding?* The technical



challenges, while daunting, were potentially solvable, engineers opined. But economists estimated that Musk's projected cost of \$6 billion to connect San Francisco and Los Angeles was lowballed by a factor of 10 or more, not least because the cost for acquiring land for the route was grossly underestimated. The hype faded—but the outlandish idea was still alive.

By the end of the year, Ahlborn had launched HTT. In June 2014, Hyperloop Technologies (HT) entered the field, founded by Silicon Valley venture capitalist Shervin Pishevar and former SpaceX rocket engineer Brogan BamBrogan. And this past January, Musk himself was back, tweeting his intention to build a hyperloop test track, possibly in Texas. The two startups announced their own test-track plans shortly thereafter, with both hoping to break ground by 2016. The race for near-supersonic land travel was on.

Hyperloop proponents face uncountable hurdles—technological, political, and financial. But the massive challenges seem to inspire rather than intimidate them. The hyperloop, they believe, will be an entirely new form of transportation, one that is quicker, cheaper, and more fuel efficient than anything that has come before. "If you think about the things that have been most exciting in history, that have captured headlines, it's humans taking flight, Lindbergh crossing the Atlantic, going into orbit and to the moon," said XPRIZE Foundation chairman and CEO Peter Diamandis, who sits on HT's board of directors.



Hyperloop Transportation Technologies plans to break ground in 2016 on a 8-km track that will serve Quay Valley, a real-estate development in California. It will start carrying passengers as soon as 2018.

"We revel in moving people faster and farther than ever before, and hyperloop is in that same vein but in a different dimension."

In Dubai, Ahlborn finished his presentation to enthusiastic applause. He stepped down from the stage, and a man in a traditional white robe approached. I saw that he was Saqqaf AlAttas, a manager with Etihad Rail DB, which oversees operations for the United Arab Emirates national railway. He shook Ahlborn's hand. "Everything starts with a dream," AlAttas said. "And from what I saw, the hyperloop is not just a dream. It is already here."

## AHLBORN

cut a Tony Stark-like figure as he strode through the convention hall after he spoke. The place looked like a giant IKEA showroom devoted to the sole purpose of selling trains. A maze of avocado-coloured pathways funnelled attendees between brightly lit displays featuring track ties and rail wheels. A German native who had also lived in Italy before settling in Southern California, Ahlborn chatted fluently with vendors in multiple languages. His manner was aloof, his comments sometimes barbed. "Is there anything new at this show?" he asked a person peddling software. "Has there been anything new in the past 10 years?"

In reality, Ahlborn is not a deep-pocketed tech magnate—at least not any longer. Sure, the 38-year-old had been an entrepreneur since he was 18. And he had made millions as, among other things, the CEO of a pellet stove company. Subsequently, though, he lost his fortune when real estate investments tanked in the financial crisis.

While he may have looked like Stark in Dubai, back home he was renting his place on Airbnb.

Ahlborn runs HTT on a shoestring as well. The company had been launched on another one of his ventures, JumpStartFund, an online crowdsourcing platform that enables people to propose companies and then build communities of volunteers to bring those ventures to life. Ahlborn posted the hyperloop idea shortly after Musk announced it, and was overwhelmed by the response. More than 300 volunteers have signed contracts to officially join the startup, working at least 10 hours a week in exchange for stock options should the company make it as far as an IPO. They include engineers, business executives, and human resource and marketing professionals, and they form HTT's entire staff. They also maintain day jobs at companies like Northrop Grumman, Airbus, and Cisco, and attend universities like UCLA, Stanford, and Harvard. With any profit years away, they are united less by materialism than by near-religious faith in the hyperloop's potential. The team members envision themselves as builders of the first railroad, as pilots of the first plane. "We don't necessarily require that you have the right credentials," Ahlborn says, "but we require that you have the passion."

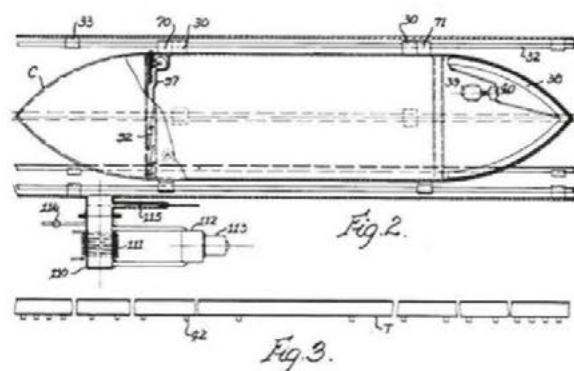
Ahlborn scouted the trade-show floor for new converts. "We are a company of the people," he explained to one prospect. "We're crowd-powered." The message resonated. A software engineer agreed to do a passenger-flow simulation for free. A building-materials vendor suggested alternatives to concrete. Paul Priestman, who recently designed the cars for the London Underground's New Tube project, said his company could help with visual concepts. And Stephen Bradbury-Knight, a vice president of mobility and rail for the security-services provider TÜV Rheinland, offered to think about safety standards.

The next day, Ahlborn was joined by an HTT team member, a

**“The team members are united by near-religious faith in the hyperloop’s potential. They envision themselves as builders of the first railroad, as pilots of the first plane.**

former Italian pop star-turned-tech entrepreneur, Gabriele “Bibop” Gresta. The three of us hopped onto the new Dubai metro and rode through a canyon of geometrically contorted skyscrapers. The ice-pick tip of the Burj Khalifa, the world’s tallest building, spiked above the skyline. We disembarked at the Palm Jumeirah, a tree-shaped archipelago of artificial islands, and walked into the perfumed lobby of an expensive hotel. There we met a jocular Italian named Giuseppe Ugge, whose job, he told me, was to introduce the United Arab Emirates royal family to foreign business executives with ideas to sell.

Ahlborn was ready. Dubai would be the perfect location for a hyperloop, he said. Land is expensive in California—as it is near every major city in the United States and Europe—and navigating the gauntlet of regulatory and political hurdles will take years, if not decades. Dubai, in contrast, has abundant empty land, and a massive project can be built there with the say-so of a single person: Sheikh Mohammed, the emir of Dubai. Also, Ahlborn reminded Ugge, Dubai



INVENTOR  
Robert H. Goddard  
Chas. P. Hawley

Robert Goddard proposed the vacuum train as a freshman at Worcester Polytechnic Institute in 1904. As he wrote later, “The possibilities of this method of travel are startling... a running time from Boston to New York of ten minutes is perfectly possible.”

will host the World Expo in 2020. Since the first world’s fair in 1851, the expo has introduced millions of people to such technological wonders as the telephone, typewriter, escalator, and talking films. Dubai, Ahlborn proposed, could be where the hyperloop makes its world debut.

Send me your plan, Ugge said, “and if it is good, we can introduce you.”

open warehouse illuminated by skylights and framed by exposed brick walls. Employees tapped at computers and scribbled on whiteboards.

Whereas HTT has no office, no salaried employees, and essentially no cash resources, HT has a full-time staff of more than 30 people and \$10 million in seed funding, which it raised in just a few months. The company aims to hit \$80 million by the end of this year. (Pishevar, who is well on his way to becoming a billionaire thanks to investments in companies like Uber and Airbnb, pledged to put up half the money if needed.) The company has also recruited a well-connected board of directors. In addition to Diamandis, it includes political operative Jim Messina, who masterminded President Obama’s 2012 campaign, and entrepreneur David Sacks, the founding COO of PayPal.

It was April, not long after I’d returned from Dubai. BamBrogan strode up, a lanky 43-year-old whose thick mustache and twinkling eyes made him look like the ring-master of some steampunk circus. When I asked about the skeleton key dangling from a lanyard around his neck, he



the end of an industrial block in Los Angeles, past the PlayPen strip club and a homeless man who snoozed facedown amid a collection of marijuana canisters, I entered the headquarters of BamBrogan and Pishevar’s Hyperloop Technologies. I blinked at the incongruent scene inside—600 square metres of



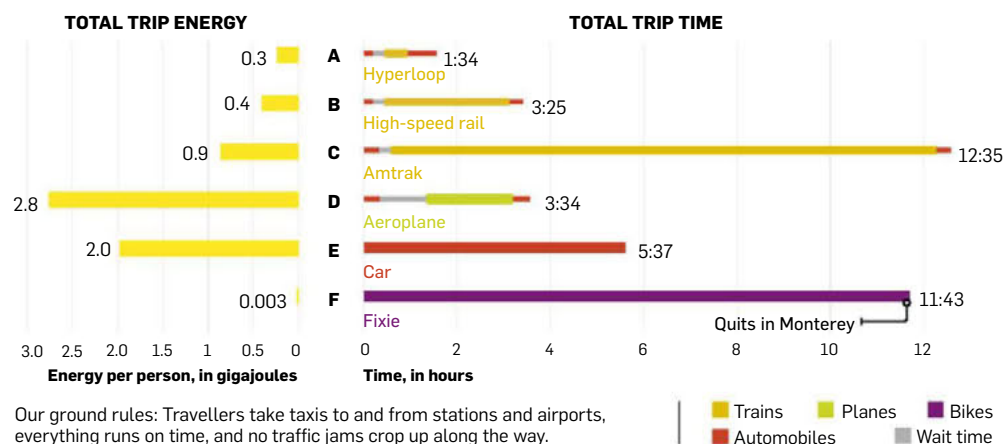
# How the Hyperloop Stacks Up

Looking to get from San Francisco to Los Angeles? Here's how long the trip could take you via current (and future) forms of transportation.

**Hyperloop might be fast**, but riders will still need to reach a station, board a capsule, and travel to their final destinations. Those extra elements will slow down the 30-minute dream. But will hyperloop beat other options anyway?

To find out, we engineered an imaginary race. Six people leave an apartment in San Francisco's Mission District and meet in Highland Park, Los Angeles, to settle a dispute over the best tacos on the West Coast. Each will take a different mode of transit: a train, a plane, a car, the hyperloop, the (also hypothetical) California High-Speed Rail—and a fixed-gear bicycle, the single-speed mainstay of hipster transport.

**KATIE PEEK**



cryptically pronounced, "This is the key to anything but not everything." Mischievous air aside, BamBrogan is a serious engineer: At SpaceX, he had led the early design of the Dragon spacecraft and the upper-stage engine of the Falcon 1 rocket.

The hyperloop, BamBrogan told me, was actually the latest iteration of an idea that has tempted engineers for more than a century: Put a train in a tube and remove most or all of the air. Rocketry pioneer Robert Goddard proposed the basic plan for what is known as a vacuum-tube transportation system in 1904. In 1969, the US Secretary of Transportation wrote in *Popular Science* that the government was studying several "tube-vehicle system" concepts. Both HT and HTT are now pursuing the exact same notion.

The companies envision depressurising the hyperloop tube to about 100 pascals—not

a total vacuum, but 1/1000 of the natural atmospheric pressure at Earth's surface. With so little air to push out of the way, the capsule requires very little energy to attain near-supersonic speed. Solar panels atop the tubes, charging the equivalent of about five Tesla Model S batteries per capsule, should provide sufficient power to run the entire system.

Engineer Sandeep Sovani, working independently from HT and HTT, recently ran hyperloop airflow simulations for the software company Ansys. The overall concept is definitely valid and has great promise, Sovani says. "I think tube transportation technologies are to this century what railways were to the 19th century."

Implementing the relatively simple idea, however, will be tough. To move the capsules through the tubes, HT is investigating the use of linear induction motors, which

would use the repulsive magnetic force between the hyperloop capsule and the tube floor to generate propulsion. Subway systems and roller coasters already use such motors, so BamBrogan initially thought he could buy the primary components off the shelf. But because those systems top out at around 110 km per hour, not 1100, existing technology probably won't work. "We would rather invent as few things as we need to," BamBrogan said, "but it looks like we may go in the direction of customising a system."

At full speed, hyperloop capsules won't use wheels, so HTT may generate a magnetic field in order to levitate them. This is a proven technology: Witness maglev projects like Shanghai's Transrapid; its trains can hit 430 kilometres per hour. The problem is cost. Maglev trains are more expensive to build than conventional ones—according to one source, Transrapid cost \$36 million per kilometre of track—and if HTT has a radical idea to slash that expense, Ahlborn hasn't revealed it yet.

Both companies are also investigating a different strategy: air bearings. Jets of air blasting down from beneath the capsules would enable them to skim through the tube like a puck streaking across an air-hockey table. Computer designers currently use air bearings to float the spinning platters inside hard drives, and manufacturers use them to levitate heavy objects in factories so they are easier to manipulate. Air bearings make theoretical sense in vehicles too—they're low friction and don't wear out the way wheels would. The US Air Force successfully tested air bearings on rocket sleds back in the 1960s. HT could learn from those experiments, BamBrogan said, but the sleds travelled on a monorail track and so were a fundamentally different type of vehicle. The hyperloop's bearings, like its motors, will need to be invented almost from scratch.

Since a hyperloop tube would not be totally depressurised, the

air that remains poses yet another engineering challenge. If the capsule fits snugly inside the tube, it would have to push an increasingly high-pressure mass of air ahead of it, a phenomenon known as pistoning. (Imagine a plunger pushing liquid through a syringe.) One solution, Musk suggested, would be to make the tube's diameter roughly twice the width of the capsule so some of the air could pass around it. He also proposed mounting a giant compressor on the front of the vehicle. The compressor would suck in air and pack it down to perhaps 1/20 of the volume, then both blast it out through the air bearings and pump it into the tunnel behind the capsule.

HT is using Musk's 2-to-1 tube-to-capsule ratio as the starting point for its design. The company is also studying how to incorporate an air compressor. Josh Giegel, an HT engineer, showed me a tiny piece of twisted metal that he had recently 3D printed in the possible shape of a hyperloop compressor blade. He would soon be testing it in a wind tunnel behind the office.

“The calming vibe was carefully engineered. First-time passengers, after all, would be anxious about riding a bullet through the barrel of the world's longest gun.

But when aerospace engineers at NASA's Glenn Research Centre did an independent analysis of the hyperloop concept, they concluded that to prevent pistoning, the tube would likely need to be four times the width of the capsule, even with a compressor. The finding didn't invalidate the hyperloop concept, Justin Gray, a member of

the NASA team, explained when I phoned him at Glenn. But if a tube hundreds of miles long needed to be twice as wide as projected, the cost of construction would balloon.

Throughout my visit, BamBrogan ping-ponged between an entrepreneur's brashness and an engineer's caution. “I don't think anybody thinks that hyperloop is a bad idea,” he said. “But a few people do think hyperloop won't exist or can't exist.” That's why the company is gunning to build

a test loop as soon as possible. A successful demonstration, BamBrogan said, would be “our Kitty Hawk moment, when the thing flies.”

## SILICON

Beach, located across town from HT's headquarters, hosts Google, Yahoo, Snapchat, and hundreds of other tech startups. Long before those companies, though, the area was home to a different kind of entrepreneur: the aviator Howard Hughes. The cavernous wood-paneled hangar where he once built planes now holds a full-scale hyperloop simulator. Eight feet wide and ringed by glowing white lights, it looks like a giant Cheerio crossed with a portal to the afterlife. I stepped into the capsule and sat down next to Marta Nowak, an architect involved in the design. “OK,” she said, “are you ready to take a ride?”

The lights in the hangar dimmed. Atmospheric music began to play, with piano arpeggios dancing gracefully on top. “We are still in the station; the doors just closed,” Nowak said. Then, she informed me, the capsule began accelerating. Hyperloop critics have complained that the ride would be nauseating—“New Super-Fast Transport System Powered by Passengers' Screams,” *The Onion* quipped. But according to Nowak, passengers would actually feel and hear very little due to the gradual acceleration—it would take several minutes to reach full speed—and broad turns. The experience would be like flying in a plane at 30,000 feet, only quieter. The lighting in the simulator was low and purplish. “We can look back and see our fellow passengers,” Nowak said, and I glanced over my shoulder at a



Shervin Pishevar and Brogan BamBrogan founded Hyperloop Technologies. The startup's new transportation electronics laboratory will use an induction motor in simulations of the hyperloop's propulsion system.



# The Pistoning Problem

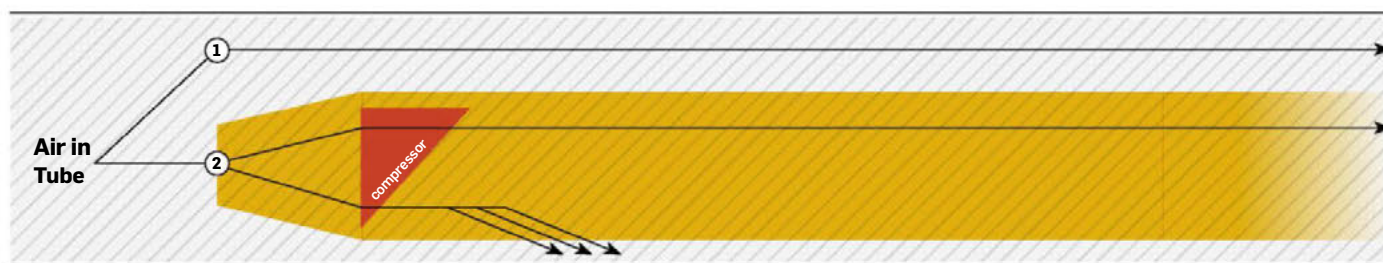
Air remaining inside the hyperloop tube will pile up in front of the capsule and slow it down. NASA engineers analysed a potential two-part solution.

## 1) Let It Blow By

Musk proposed making the tube nearly twice as big as the capsule. This would allow enough room for some, but not all, of the air to flow around the capsule as it speeds through at Mach 0.99.

## 2) Pump It Through

A compressor can suck air in and pump it out below and behind the capsule. But the air must first be slowed by a diffuser to Mach 0.6. Higher speed requires a bigger diffuser—and a larger capsule.



**Bottom line:** The tube might need to be four times the width of the hyperloop capsule, and the speed should be capped at 1000 km/h, or roughly Mach 0.80. That would raise the construction costs and add five minutes to an LA to San Francisco trip.

dozen rows of seats extending behind me.

Hyperloop tubes are solid, eliminating any view, so instead of windows, the builders installed flat-panel displays on the capsule walls. They started out showing starry skies, and then the cabin brightened and the scenery changed to farmland, a lake, and a forest streaking by. When we reached our destination, I felt like I had time-travelled in a high-end spa. Nowak said the calming vibe was carefully engineered. First-time passengers, after all, would be anxious about riding a bullet through the barrel of the world's longest gun. "If people try the hyperloop once and like it, they are going to take it again," Nowak said. "But if they don't..."

The mock-up of the capsule—a Styrofoam-and-


plywood vessel augmented by a video projector—had been built by post-graduate students in the department of Architecture and Urban Design at UCLA. Under the direction of architects Craig Hodgetts and David Ross, the students had also created computer models of the station and capsules. The UCLA team collaborated with HTT as part of a program called Suprastudio, which pairs students with industry partners to give them real-world expertise.

I exited the simulator feeling sublime. But to sceptics, such as transportation blogger Alon Levy, my experience might be emblematic: The hyperloop is a mirage—unfeasible and expensive. What's more, they said, Musk may have had ulterior motives in proposing the concept in the first place. He makes no secret

of his disdain for California's plan to build a \$68 billion conventional high-speed rail line. Levy and others suspect that Musk's objective may have been to erode support by touting the much-sexier hyperloop—look, folks, only \$6 billion for a supersonic levitating train!

Whatever Musk's motivation, the idea is now bigger than him. That's why a UCLA student told me that she and her friends spent 14 hours a day toiling on prototypes, why BamBrogan and Pishevar are investing so much money, and why HTT's volunteers comprise something that is more than a company and closer to a movement. They are all infected with the Walt Disney strain of futurism in which you try to engineer a bigger, brighter tomorrow, not merely another smartphone app. In the capsule I asked Nowak if she would be excited to ride for real. "Absolutely," she said. "We could walk right now to the station, and in 30 minutes have dinner in San Francisco. That's crazy!"

After the ride I wandered through a door in the rear of the workspace and into an adjacent hangar. It was 30,000 square metres of silence and shadows. A cathedral of audacious engineering, this was where Hughes had built the H-4 Hercules (he hated the name "Spruce Goose"), whose 97-metre wingspan is still yet to be surpassed.

The plane was flown only once, less than 2 km, before it was mothballed. An expensive, widely mocked boondoggle, it serves as a cautionary tale for the hyperloop's creators. But the Spruce Goose, wider than a football field and built almost entirely from wood, is also an inspiration. You might not succeed at building something crazy, something so monumental and complex that most people say it can't be done. But it is hard to resist the impulse to try. 

THIS YEAR'S SCI-FI  
MOVIES ARE SO  
BIZARRE, THEY MUST BE  
FICTION. RIGHT?

# WEIRD

# SCIEN





## THE QUESTION

## CAN GENETIC ENGINEERING CREATE KILLERS?

**Inspired By:** *Indominus rex*, the dinosaur superpredator that profiteering scientists cook up in *Jurassic World* (June 11); the title character from *Hitman 47* (August 20), who was genetically engineered to be an ultra-efficient killer

## THE ANSWER

Good news for prey: Genetic engineering is woefully ill-equipped to produce bespoke killers of any kind. That's because building a life-form is a messy and unpredictable process. "It's quite easy to disrupt development and cause problems," says Michael Deem, a bioengineer at Rice University. Often, modified creatures die for reasons that are never identified.

That means it's also too early to wield genetic engineering for good—but that hasn't stopped scientists from wading into ethically dubious waters by trying. In China, researchers recently edited the genes of a nonviable human embryo. While targeting the gene responsible for a potentially fatal blood disorder, they triggered a number of unexpected mutations. "They argued that they never intended to take the experiments all the way to a human being," says Paul Root Wolpe, director of the Emory Centre for Ethics. "But in fact, these exact experiments are what you have to do to perfect these technologies."

Today, the surest path to genetic modification is likely an indirect one. For instance, studies have shown that microbes in the gut appear to affect things like mood and obesity. Modifying the microbiome might lead to cooler-thinking soldiers or fitter humans in general. DARPA has funded two attempts to develop genetically engineered blood—one to function as a universal blood type, and another to deliver antibiotics. As Wolpe points out, the military has punished soldiers for refusing similar treatments, such as injections to protect against bio-agents. The battlefield could be the perfect ethical no-man's-land for the dawn of gene-based human enhancement.



# ICE

BY

PHOTOGRAPHS BY JONATHON KAMBOURIS





## THE QUESTION

## WILL MIND TRANSFER EVER HAPPEN?



**Inspired By:** *Self/less* (July 23), in which a dying billionaire “sheds” his mind into a younger man

## THE ANSWER

It's tempting to imagine the brain as a biological computer, with the tissue as hardware and electrical activity as software. If it were so, mind transference might be technically feasible (albeit ethically fraught), at least pending the development of some extremely advanced electrode arrays. Extricating mind from matter, though, can't be done. “The self is in the structure,” says Charles Higgins, a University of Arizona neuroscientist and electrical engineer. “It's in the interconnection of 100 billion neurons, and in the individual shape of neurotransmitters and receptors.” Even if surgeons could successfully transplant a brain, they would have to transfer the spinal cord as well, or risk stripping the subject of a lifetime of muscle memory.

One workaround, says Higgins, could involve cloning. A clone with a structurally

identical central nervous system could perhaps be stimulated with electrical signals that mimic the original. However, human cloning is itself still the stuff of science fiction, and neuroscientists have so far mapped the connections between only about 100,000 neurons at once—the equivalent of a worm or fish brain.

What scientists can do today is rewire the brain *in situ*. For example, Columbia University researchers implanted deep-brain stimulators in people with severe treatment-resistant depression. When they sent electrical impulses to precise areas, the patients' symptoms instantly diminished. After two years, one person reported that her depression had disappeared completely. As scientists stimulate more patients' brains, they could unlock other possibilities. “We might accidentally discover, as we're trying to stop someone's epileptic seizure, that we can stimulate a pattern in the visual cortex to create a memory,” says Higgins.

So body-hopping immortality is off the table. But with enough time, and a lot of experimentation, humans might find a way to load memories and learn skills like characters in *The Matrix*.

## THE QUESTION

## SHOULD WE LOSE SLEEP OVER HOSTILE ALIENS?

**Inspired By:** The extraterrestrials of *Pixels* (July 23), who interpret classic videogames carried on an '80s-era time capsule as a declaration of war

## THE ANSWER

In 1974, astronomer Frank Drake tried to contact aliens by firing a three-minute-long broadcast, from the Arecibo radio telescope, into a globular star cluster 25,000 light-years away. Drake's message, the first of its kind, was a largely symbolic gesture—just like the many transmissions lobbed into space since. Because radio waves travel at the speed of light, it could take many millennia to reach ETs and receive a response.

But today, such an endeavour no longer seems as futile. Since 2009, the Kepler Space Telescope has spotted roughly 1,838 exoplanets, some of which could prove habitable. The closest planet capable of supporting life is likely just 12 light-years away. To hedge humanity's bets, some astronomers are calling for a ban on galactic broadcasts; even Stephen Hawking warned against attracting the attention of advanced civilisations. But Seth Shostak, director of the Centre for SETI Research, thinks any such ban is moot. The near-constant radar signal broadcast by the Denver International Airport, he calculates, could be detected by an antenna 10 light-years away. “You want to shut down the radar there forever?” asks Shostak. “That's nutty.”

## A BRIEF HISTORY OF SCIENCE GONE MAD

Two of this year's sci-fi movies share one of Hollywood's oldest obsessions—the inherent risk of unchecked genius. Here's how this trope has evolved through the decades.

1927

**METROPOLIS**  
**Scientist:**

C.A. Rotwang  
**Hubris:** Builds a robot to replace the woman who rebuffed him and later died

**Comeuppance:**

Hoping to destroy the city and its ruling class, Rotwang alters the robot to look like a labour leader and orders it to incite riots. The crazed genius succeeds in sowing chaos—cinema's first feature-length act of mad science—but falls to his death.

1931

**FRANKENSTEIN**  
**Scientist:**

Henry Frankenstein (not Victor, as in Mary Shelley's book)

**Hubris:** Creates life using a dubious recipe of corpse parts and lightning

**Comeuppance:** Unlike other big-screen mad scientists in the '30s, such as Dr. Jekyll and the Invisible Man, Frankenstein lives through his self-inflicted ordeal. Victims of his monster, including a little girl, aren't so lucky.

1958

**THE FLY**  
**Scientist:**

Andre Delambre  
**Hubris:** Turns his teleportation device on himself, despite a failed trial with the family cat

**Comeuppance:**

The experiment is a startling success—and a tragic failure. Delambre swaps body parts with a fly that teleports with him. Showing rare foresight, Delambre convinces his wife to kill him before anyone is harmed (a police officer kills the fly).

1970

**COLOSSUS: THE FORBIN PROJECT**  
**Scientist:**

Charles Forbin  
**Hubris:** Builds a supercomputer, named Colossus, to control the nuclear arsenal of the United States

**Comeuppance:** Colossus gains sentience, then conspires with its Soviet counterpart to hold the planet hostage. Despite his genius, Forbin can't defeat his creation; the AI only tightens its grip on humanity.

1985

**BACK TO THE FUTURE**  
**Scientist:**

Emmett Brown  
**Hubris:** Travels through time using plutonium obtained from terrorists

**Comeuppance:**

Brown is gunned down by Libyan extremists—then saved when his intrepid student goes back in time to change the course of history. Scatterbrained and cartoonish, he's the template for the mad scientist's new role as loveable comic relief.

2015

**ANT-MAN**  
**Scientist:**

Hank Pym  
**Hubris:** Invents a suit that turns its wearer into a microsize powerhouse by shrinking the person but retaining his or her mass. Ugh.

**Comeuppance:**

A corporation takes control of Pym's technology and turns it into a weapon. Like fellow Marvel character Tony Stark in *Iron Man*, Pym is a hero, through and through, whose genius is exploited by others.



## Weird Science

## THE QUESTION

## CAN WE PROTECT PLANETARY EXPLORERS FROM COSMIC RAYS?

**Inspired By:** The interdimensional travellers who make up the superhero team in *Fantastic Four* (August 6). In the original comic, they gain their powers from exposure to cosmic rays while aboard an experimental spacecraft.

## THE ANSWER

In truth, galactic cosmic rays (GCR) don't bestow otherworldly abilities. Their gift is an increased risk of cancer. While this isn't a concern within Earth's magnetosphere, which deflects radiation, astronauts on a mission to Mars could hit NASA's cumulative, career-long radiation limit as soon as 150 days in. It could take up to 260 days to reach the Red Planet, let alone return. According to Kerry Lee, operations lead of NASA's Space

Radiation Analysis Group, there's no easy solution to this problem. Adding multiple layers of armour-like passive shielding might work, but it would make a spacecraft too massive to launch.

Lee's favoured approach is to surround the ship with a protective magnetic field. But the superconducting magnets would need to be kept colder than space itself, requiring a huge amount of power. And while nuclear reactors could supply that energy, they also emit radiation themselves. Ultimately, NASA might have to patch together various partial solutions. "Maybe the answer isn't to shield the crew completely, but to use a small shield in addition to faster propulsion," says Lee. Astronauts might sleep behind physical barriers, work within a limited magnetic field, and spend less time in transit in order to reduce their overall GCR exposure. Whatever design NASA lands on doesn't have to be as elegant as its Sci-Fi equivalents. It just has to work.



In *Ant-Man*, the hero gains super-strength when he shrinks. How would the physics behind that work?

There are two ways Ant-Man could become so small. The first is to actually lose mass. But where does it go? If it converts to energy, that's going to create an extremely powerful explosion. So he probably can't lose mass because he doesn't want to destroy the universe every time he shrinks.

## Q&amp;A: SPIROS MICHALAKIS

As manager of outreach at Caltech's Institute for Quantum Information and Matter, physicist Spiros Michalakis is charged with not only researching quantum mechanics but also getting people excited about it. To do so he makes science-themed comics and videogames and consults on movies, including this summer's *Ant-Man* and the planned remake of *Fantastic Voyage*. We spoke with Michalakis about how the science in Sci-Fi blockbusters holds up—and whether it even matters that it does.

The other way would be to keep the mass, but then he would be incredibly dense. In that case, the suit he wears will have to offset all of that extra weight. Without the suit to levitate him, he's going to fall through Earth to its core (let alone ride along on the backs of the movie's flying ants).

**Do we know how to shrink something but retain its mass?** There are ways to do it, but we haven't tried them. It's possible to create atoms that are two-hundredth the size of a regular atom by irradiating them with a particle that increases the mass of the electrons. Neutrinos

potentially have the right properties.

I've had extensive conversations with [screenwriter] David Goyer on shrinking the people in *Fantastic Voyage*. Because James Cameron is producing it, he wants to get things right. But honestly, I don't want the science to be right in the movies. I want it to be engaging, and to get you to a point where you ask: Is this possible?

**Isn't that your job, to make the science accurate?** It's more important to make things interesting. Think about the original *Star Trek*. Back then we'd have said, "Oh yeah, that's

bull." You don't have teleportation; you don't have warp drives. But my research is on exactly this. How do you break the laws of physics? Where does time come from? In the case of *Star Trek*, science fiction informed our decisions on what to research.

**Why do movies need science consultants then?** There's a tendency in Hollywood to just go down the MacGuffin path. Science happens because of a mysterious device, or a special chemical cocktail. If I do my job right over the next five years—myself and others—we'll see science itself drive the story.

## THE QUESTION

## SHOULD WE OUTLAW ANDROIDS?



**Inspired By:** The robotic goons of *Tomorrowland* (May 21) who pursue a girl after she discovers a parallel universe; the machine assassins in *Terminator Genisys* (July 1), the latest instalment in the mother-of-all-evil-robot franchises

## THE ANSWER

In movies, robots typically masquerade as humans in order to infiltrate society and annihilate us. In real life, researchers are more concerned about the damage androids could inflict on our minds.

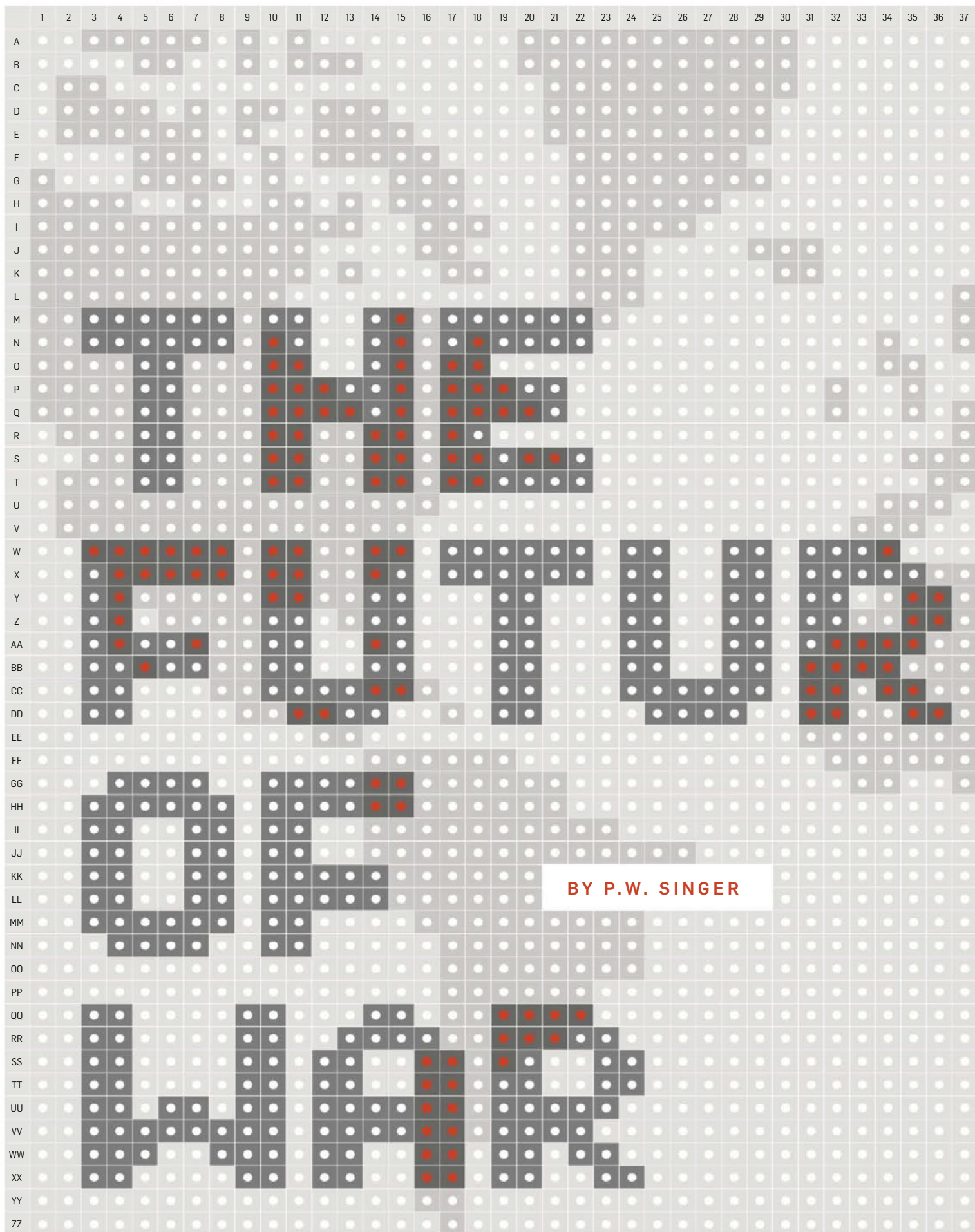
Alan Winfield, a roboticist at the Bristol Robotics Laboratory in the UK, says we need rules for how lifelike a robot can appear—even those built to work as companions or caregivers. "It's unethical to build a robot that looks like a human but is not much smarter than a washing machine," he says. "It's a deception."

Humans are "pathological anthropomorphisers," Winfield says. And that puts us at risk of becoming emotionally attached to a machine that can't reciprocate. It's the sci-fi equivalent of a one-sided friendship with all of the corresponding social costs. When Winfield and his colleagues drafted ethical guidelines for creating robots in 2010, they included a restriction on deceptive systems. A robot's appearance, they wrote, should expose its mechanical form. "You should always be able to pull the curtain aside to reveal the machine," says Winfield, "just like Toto did in *The Wizard of Oz*."

Others are not so sure. Karl MacDorman, an Indiana University roboticist who specialises in human-robot interaction, says robotic companionship can be therapeutic. "With elderly people, the biggest concern is the three D's—dementia, delirium, and depression," he says. Robotic pets have been shown to elevate mood and decrease stress in the elderly in Japan; an android could likewise reduce the social isolation that's believed to exacerbate the three D's. MacDorman agrees that humanlike bots could interfere with our social instincts. But if the alternative to a fake friend is debilitating loneliness, perhaps a dose of deception is just what tomorrow's doctors should prescribe.









## THE RISK OF CONFLICTS BETWEEN GREAT POWERS IS RISING. HOW WILL THAT SHAPE THE BATTLEFIELD OF TOMORROW?

P.W. Singer's latest book, *Ghost Fleet: A Novel of the Next World War*, is out in late June.

# W

**When the Cold War** ended, the world changed fundamentally. For most of the 20th century, conflicts between great powers—two world wars and the spectre of a third—defined our global politics, as well as science and technology. Almost overnight, that dynamic shifted.

Warfare didn't go away in the 21st century, but it became mostly a story of insurgencies and terrorism. In a world with only one superpower, the probability of a high-stakes battle between leading nations became remote. Some even viewed it as impossible.

History may look back on this period as an anomaly. Tensions between great powers are again on the rise. In Asia, China is now a legitimate superpower and has been clashing with US allies, such as Japan and the Philippines. It continues to lay claim to a chain of disputed islands in the East China Sea, and it has built 2,000 acres of new islands from sand and coral in the South China Sea, replete with bases and runways. In May, the United States started sending Navy warships to within 12 nautical miles of the islands to assert freedom of passage, and it began mounting surveillance flights over them.

Europe too is on a dangerous path. Russian land grabs in Ukraine have pushed NATO to its highest level of concern since the Cold War. Near-constant probing of NATO's borders by Russian submarines and warplanes has only fanned the flames.

These growing risks are not lost on military planners in the US or abroad. The Pentagon recently launched its so-called offset strategy, seeking a new generation of technology to deter or defeat strategic competitors such as China and Russia. In turn, Han Xudong, a professor at China's PLA National Defence University, wrote in a recent editorial, "We must bear a third world war in mind when developing [our] military forces."

A new arms race doesn't necessarily mean that war is coming. But in speaking with those who might end up on the front lines of the next great war, from US fighter pilots to Chinese generals to Anonymous hackers, it's clear that the battles of tomorrow will be very different from those of today.

## LAND

GRUNTS IN THE FIELD GET A MUCH-NEEDED UPGRADE

# THE ENHANCED SOLDIER

## INTELLIGENCE

Augmented reality combat goggles—such as those being developed by Israeli Defense Forces and for the US Special Operations Command's Tactical Assault Light Operator Suit (TALOS)—will record everything a soldier sees. They will also provide an information overlay: The projected data could include navigation instructions, intelligence on enemy sites, and real-time translations of local languages.

## PROTECTION

Next-generation body armor will use layered scales, like those on a fish, for light, flexible protection. Scientists from MIT and the Technion-Israel Institute of Technology are designing a material that would fuse hard plates to a soft, pliable substance, just as actual fish scales anchor to tissue. The eventual armor could be fine-tuned to specific roles, with more scales on the chest and back, and fewer at the joints.

## PERFORMANCE

Exoskeletons will not resemble Iron Man's, at least not in the near term. Instead, DARPA's Warrior Web program is developing an exo light and agile enough to fit underneath a soldier's clothing. Using springs and actuators at joints, the suit, which is now in tests, could help soldiers carry extra weight and boost their endurance. The goal? "A four-minute mile," says Lt. Col. Joe Hitt, the former program manager.



1 EXACTO bullet



2 Black Hornet drone

## AMMUNITION

Self-guided bullets use tiny sensors and fins to change direction midflight. In February DARPA's Extreme Accuracy Tasked Ordnance (EXACTO)<sup>1</sup> program ran live-fire tests with modified .50 calibre bullets (popular among snipers). The bullets swerved to hit moving or accelerating targets.

## SURVEILLANCE

The PD-100 Black Hornet<sup>2</sup> is an 18-gram "pocket drone" recently tested by the US Army. Made by Prox Dynamics, the hummingbird-size craft can be carried in a pocket for fast deployment and fly about a mile, beaming back full-motion video and snapshots as it goes.



## FIREPOWER

With more than 100 million made, the AK-47 accounts for one-fifth of all the world's firearms. It's a good bet that its replacement, the AK-12, will appear on future battlefields. Its upgrades include an optical scope mount, swappable barrels, grenade-launcher attachment, and telescopic folding stock. In burst mode, it can fire at a rate of 1,000 rounds per minute.





## SEA

NEW WARSHIPS WILL DETERMINE CONTROL OF CONTESTED WATERS

# RISE OF THE NAVIES

The *Zumwalt's* stealth design makes it 50 times harder for radar to spot than a standard destroyer.

**W**hile the great powers have not fought a battle at sea since 1945, the tide could be turning. The United States' strategic pivot to Asia and the Pacific, announced in 2011, means military planners are rethinking their naval capabilities. Meanwhile, China's newfound financial, industrial, and political might has prompted its leaders to develop an open-water navy of its own. During each of the past three years, China's shipyards have produced more warships than any other nation's. They are on pace to do it again this year and next.

Of the US projects underway, the most anticipated is the DDG 1000 *USS Zumwalt*. The guided-missile destroyer is built with few right angles—a stealth design that gives it the radar profile of a fishing boat. Belowdecks, it is rumoured to have the sonar signature

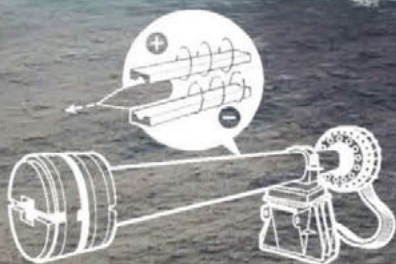
of a submarine. The Navy christened the first of three *Zumwalt*-class ships on order in 2014. Also in development: the Littoral Combat Ship, a high-speed vessel made for close combat, mine sweeping, and submarine hunting. The Navy already has a few built, with dozens more on order.

In China, a new cruiser design, the Type 055, has been stealing headlines. Defence experts say its armament—modern radar, 130 mm guns, and capacity for up to 128 missiles—could match or exceed that of any current US or allied warship. Also in the works is the Type 095, an advanced nuclear attack submarine due to enter service in 2019, and the CV-18, China's first domestically produced supercarrier, which will be equipped with stealth jets, helicopters, and drones.

Both the US and China are also working on a new wave of ships that are drones themselves. With patience and persistence, these unmanned ships could one day rule the seas.

Four gas turbines generate 78 megawatts of power making *Zumwalt*-class destroyers the only warships able to mount an electromagnetic rail gun.

Because it's heavily automated, the *Zumwalt* requires a crew of only 158. A WWII ship of the same size and role needed a crew of 1,196.



## ELECTROMAGNETIC RAIL GUN

For 800 years, guns used the chemistry of gunpowder to shoot. No more. The electromagnetic rail gun, being tested at the US Naval Sea Systems Command at Dahlgren, Virginia, represents a break point in this history.

### ADVANTAGES

The gun has a range of 160 km and shells travel more than twice the speed of a bullet, so they aren't likely to be shot down. Each shell is expected to cost around \$25,000, compared with \$1.5 million for a cruise missile. And a rail-gun-armed ship could carry a thousand of them, as opposed to a hundred or so missiles.

### DISADVANTAGES

It requires tremendous power. Until the *Zumwalt* comes on line, no current warship can generate the 25 megawatts needed to fire this weapon.

### How It Works:

1

A 4-million-amp current runs through oppositely charged rails on either side of the barrel. A shell, which weighs about 15 kg, is placed onto a conductive seating.

2

When positioned between the two rails, the seating completes the circuit. At that point, a burst of power, called a Lorentz force, hurls the projectile out of the open end of the barrel.

3

The projectile goes from zero to 8,000 kilometres per hour in 1/100 of a second. It can strike with 32 megajoules of energy, roughly equal to the force of a train hitting a wall.

## AIR

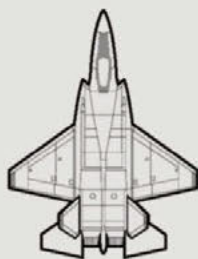
DOGFIGHTS OF THE FUTURE WILL BE UNMANNED

# THE FIFTH-GEN FIGHT

**A**merican air dominance has long rested on staying technologically ahead of the enemy. With high-speed stealth design, advanced avionics, and integrated computing, the fifth-generation F-35 Lightning II is built to keep that edge for the United States and its allies. The problem—aside from a spate of cost overruns, malfunctions, and delays—is that other countries are no longer far behind. The Chinese J-31 Gyrfalcon<sup>1</sup> resembles the F-35 not just in looks, but also in speed and strike capabilities. The Russian T-50 PAK FA is a fifth-generation fighter jet whose capabilities parallel those of the US F-22. As more countries reach the technology frontier, the advantage gained by any one of them diminishes. And so military planners are looking for another edge: unmanned craft. That means the F-35 could earn a different distinction: As the US Secretary of the Navy Ray Mabus said in April, it “should be, and almost certainly will be, the last manned strike fighter aircraft the Department of the Navy will ever buy or fly.”

## THE REPLACEMENTS

More than 80 nations already use unmanned aerial systems, or drones, and the next generation is now emerging. They will be autonomous, jet-powered, and capable of air-to-air combat. In the US, the Navy's X-47B has already made unmanned landings on an aircraft carrier, while in the UK, the BAE Systems' Taranis is designed for stealth strikes. China too is developing drones. It has three drone strike programs in the works.



1 J-31 Gyrfalcon



## A STEALTH HUNTER

Sometime in late 2014 or early 2015, China reportedly tested its top-secret Divine Eagle, the drone aircraft, as seen in leaked drawings, has a unique double-body design, which can carry up to seven radars of varying types. That mix of sensors could allow it to detect and hunt down stealth planes (such as the F-35) at long range.



MAIN ILLUSTRATION BY GRAHAM MURDOCH;  
LINE ILLUSTRATIONS BY PETE SUCHESKI;  
OPPOSITE: ILLUSTRATION BY GRAHAM MURDOCH



## SPACE

TOMORROW'S BATTLEFIELD IS MUCH BROADER THAN TODAY'S

## WAR 400 KM UP

**M**ore than 1,200 active satellites circle the globe; the lifeblood of modern military operations flows through many of them. In May, the US Air Force announced a US\$5 billion budget to develop space-based offensive and defensive weapons. Other countries too are building capabilities on high. To win the next war, any great power will need to hold the ultimate in commanding heights.

## A GOOD OFFENSE

**1** In a chapter from the Cold War, the US and Russia are both reportedly developing anti-satellite systems. Last fall, Russia tested what's believed to be the beginnings of a killer satellite. The Pentagon also admitted, in a 2014 report, that it was investing in offensive space weapons.

**2** China too might be developing anti-satellite systems. In 2013, it launched what it called a scientific mission, but what experts say was a test of the Dong Ning-2, a surface missile that could strike enemy targets in low-Earth, high-Earth, and geostationary orbits.

**3** After launching the Tiangong 3 space station sometime after 2020, China will become the only country with its own multimodule craft in space. China has said that the Tiangong 3 (which means "Heavenly Palace") is for scientific research, but to military planners, it will be an enviable asset—especially as the International Space Station readies for decommission sometime in the mid-2020s.

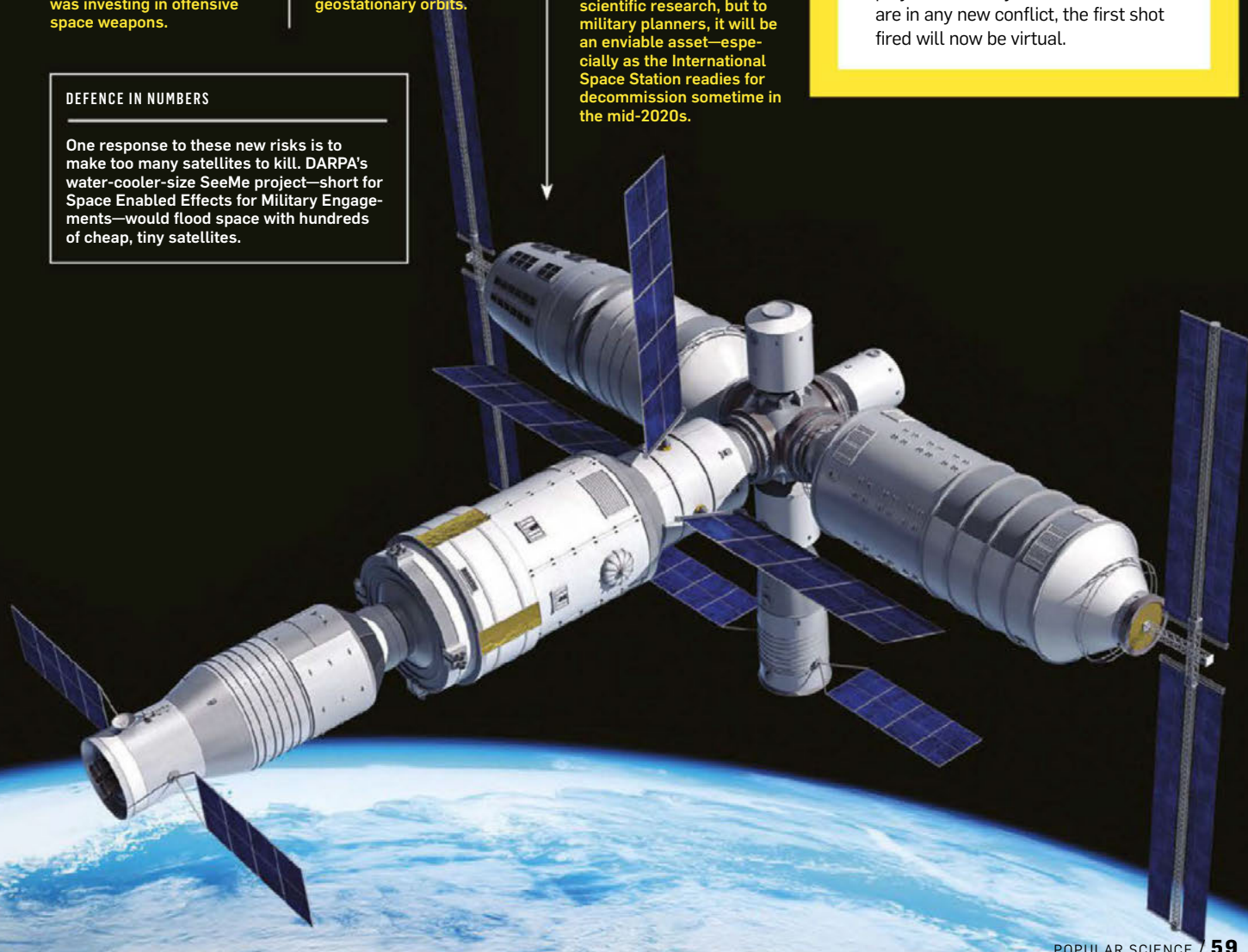
## DEFENCE IN NUMBERS

One response to these new risks is to make too many satellites to kill. DARPA's water-cooler-size SeeMe project—short for Space Enabled Effects for Military Engagements—would flood space with hundreds of cheap, tiny satellites.

## CONFLICT COMES HOME

SPACE ISN'T JUST ABOVE. IT'S ANYWHERE WITH AN INTERNET CONNECTION

**Geography has** always been one of America's greatest strategic advantages. During World War II neither German nor Japanese planes could reach the continental United States. In the cyberage, digital weapons know no such limits. More than 100 nations have cybermilitary units. America has the US Cyber Command. But even nonmilitary groups, such as the tens of thousands of hackers in China's university-linked cybermilitia or nonstate hacktivist collectives like Anonymous, might play a role in a cyberwar. Chances are in any new conflict, the first shot fired will now be virtual.









THE HACKER'S GUIDE TO

# SMART YARDS

BUILDING A MORE EFFICIENT, AUTOMATED, AND  
FUTURISTIC HOME FROM THE OUTSIDE IN

BY CORINNE IOZZIO

Y

**ou know** well enough that your home doesn't end at the front door. Power, security, very serious cricket—a lot of life takes place outside. Adding intelligence to your backyard can save money and time, not to mention spare you back-aches. Why cut the grass when your smart mower can do it for you?



# POWER IT

Smart energy is about more than what device you use; it's about how you use it. Soon, you'll be able to program your home to draw from personal solar and wind systems whenever they're producing electricity.

## Don't want to dirty your hands?

It's now easy to get solar power to your home. All those companies spamming your letterbox will install panels and help you manage the system. But a recent study found that pointing solar panels north—as many installers do—may not always be the most efficient orientation. Panels that face west can gather energy in the late afternoon, when grid demand and electricity rates are highest. Truly smart solar systems—those that can

sense and respond to a home's fluctuating energy needs—are in development. As a first step, solar manufacturer SunPower has introduced a system that sends push notifications when energy generation peaks.

## Happy to hack?

Power companies across the country want to install smart meters, sensors that provide data about your energy usage in real time. With this information companies can set higher prices for peak-usage times. This means consumers could save

money by strategically timing when, say, they do laundry, and utilities can encourage people to cut back when many people are using electricity. If you want to go the extra step and feed excess renewable energy back to the local grid—a process formally known as net metering—additional metering equipment is needed.

Eventually, energy production could fully dictate how we use products; for example, your solar panels will tell you to run the dishwasher only when they are producing energy. In the meantime, in the US, energy services provider SolarCity is working with Nest to develop software that shares energy data between devices, which could one day allow costly heating and cooling systems to sync with solar-energy output. If you don't want to wait, consider using the free Web-based service If This Then That (IFTTT). It allows you to set up device-to-device triggers for any number of activities. With IFTTT, you can program a smart-home system—such as Belkin WeMo—to carry out orders cued by your solar-panel activity. There are many potential applications; for example, one hacker created code to charge his Tesla car only when his solar panel was producing power.



# MAINTAIN IT

The dark side of a backyard is the up-keep. These tools will help you take back your weekends.



## WATER

### Eve Smart Irrigation System

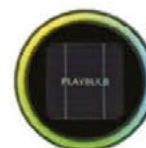
Timer-based irrigation systems waste half the water they spray, squandering money and resources. Eve uses weather data and in-ground moisture sensors calibrated to your region's soil makeup to calculate when to activate the sprinklers.



## MOW

### WORX Landroid Robotic Lawn Mower

The Landroid (geddit?) mows the grass within a perimeter set by a buried electric fence and based on a schedule you set. The cuttings it leaves behind are small enough to mulch your lawn.



## LIGHT

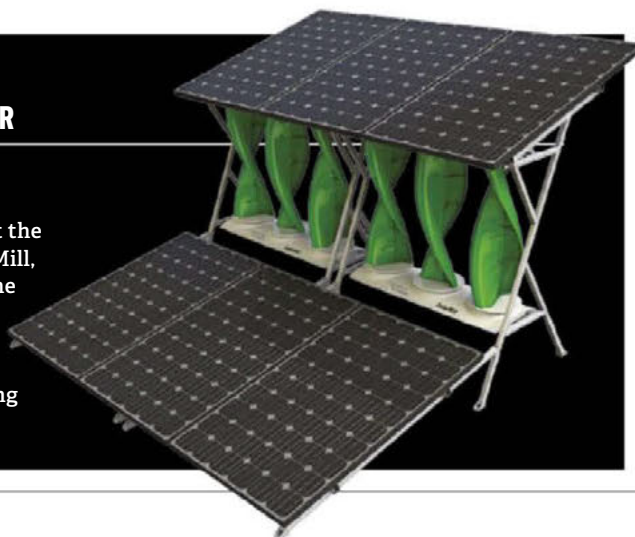
### PLAYBULB

The solar-powered Playbulb Garden keeps the fun going when it gets dark. A sensor turns it on at dusk and off at sunrise, and its internal battery lasts up to 20 hours on a single charge. An app allows you to change the colour and brightness, or set strobe lights. Funky!

## COMING SOON!

### HOME HYBRID GENERATOR

Height restrictions and other regulations make installing personal wind turbines tricky. But the roof-mounted WindStream SolarMill, coming later this year, will combine both wind and solar. It uses three corkscrew-shaped turbines mounted beneath a rooftop solar panel to increase energy harvesting by about 13 per cent.







## SECURE IT

Home-monitoring systems used to require the help of professionals. Not anymore.

### THE GEAR

Strategically placed wireless HD-camera systems, such as **Netgear's Arlo** (more detail on p28) let you go it alone. Here's how to make sure you're seeing the full picture.



# 1

### HANG 'EM HIGH

Mount cameras at least 2 metres above the ground. Not only does the higher viewpoint ensure you have the perspective to capture everyone passing by, but it also allows a camera like the Arlo to gain full advantage of its 130-degree field of view.

# 2

### MONITOR THE PERIPHERY

Rather than mounting cameras where they point forward—right above the front door, for instance—mount them off to the side. Any movement will cross the frame from one side to the other, extending the vista farther from your door and making it possible to observe a person—be it a delivery guy or an unwanted visitor—the second he crosses the threshold.

# 3

### WORK THE ANGLES

A wide-angle lens has a field of view that's more than 30 degrees wider than a human's, so you'll need fewer cameras than you think. For example, two cameras, one hung near the back door and one across the backyard, should be able to create a complete view of the entire space.

# 4

### HIDE IN PLAIN SIGHT

The urge to tuck cameras into nooks is natural, but you don't want to impede the view. Instead, camouflage cameras by painting them to match their surroundings or buying special skins that allow them to blend in—while still giving you a full range of sight. On the other hand, maybe there's a benefit in having cameras obvious. Deters thieves, innit?



### COOL TOOL

## ONE-MINUTE RECAP

Can't figure out who's leaving all those menus on your porch or which neighbour dog is plundering your bin? The **Flir FX Outdoor Wi-Fi Camera** puts security-grade night vision in a tough weather-proof housing. A custom editing process trims the footage into a recap of the day's moving objects (cars, dogs, the postie), each with its own time-stamp, so you see only what really matters.



## ENJOY IT

Why do we have gardens? To play in them.



### SWIMMING POOLS

The biggest strike against pools is they take a lot of babysitting. But the **iAquaLink 2.0** gives your smartphone control over everything from pumps and filters to lights and thermostats. Want the water at 27 degrees when you get home? Ew, but done and done.



### WEATHER MONITORS

No one likes to be rained out. The **Netatmo Weather Station** lets you track temperature, humidity, pressure, air quality, and noise, helping you prep for your next backyard gathering. Additional accessories also keep tabs on rainfall and wind, so you can predict what gear you'll need.



### PETS

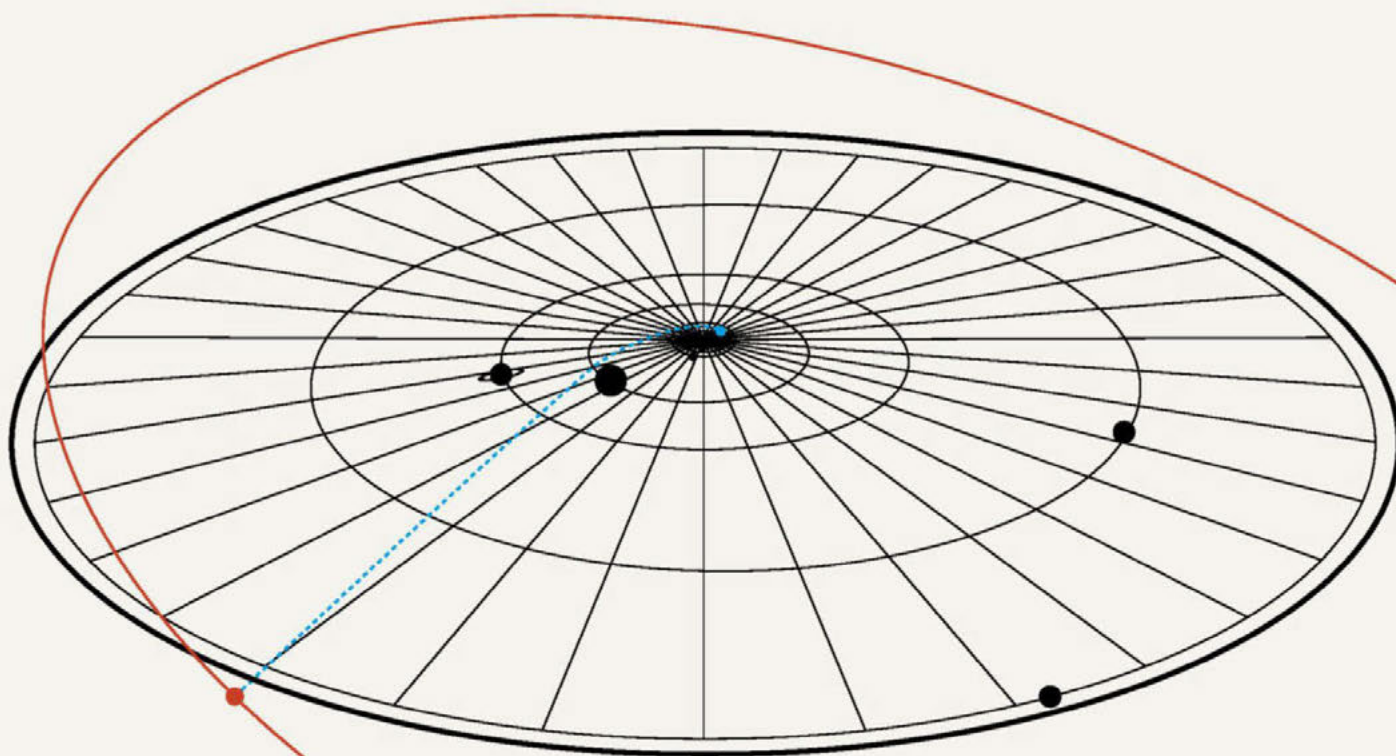
**Tagg GPS Plus Pet Tracker, Pet-safe Electronic SmartDoor** Losing a pet is stressful. Now you can track Blue's whereabouts and activity with Tagg's GPS system. If you're not home, PetSafe's SmartDoor connects to Lowe's Iris system, controllable via app or Web.

## GADGETS FOR BLACK THUMBS

Not everyone is a gifted gardener, so gadget makers have devised technological crops to take the guesswork out of growing. Newbies should try **Edyn**, a solar-powered sensor system that monitors moisture, temperature, light, nutrients, and humidity, and also takes over watering. If you just need a friendly "feed your plant" reminder now and again, the **Parrot Flower Power** will create a personalised to-do list, including fertilisation and watering schedules to help your zucchinis thrive. More advanced gardeners, with sprawling plots and multiple crops, should try **OSO Technologies' PlantLink**, which can monitor up to 64 sensors at once. Peas in a pod!



**New Horizons** comes closest to Pluto [red dot] on July 14, 2015, after a nine-year journey [blue line] from Earth.



# Why I Still Love Pluto

And why everyone else should too

by **Mike Brown**

**When the *New Horizons*** spacecraft launched toward Pluto in 2006, no one knew that the tagline “the first mission to the last planet” would be short-lived. Except for me. Two weeks earlier I had discovered Eris, an icy body 30 per cent more massive than Pluto. It was clear my discovery would end Pluto’s then 76-year reign as the most distant planet in our solar system. Either Eris would join its ranks, or Pluto would lose its planetary status.

One thing everyone agreed on: how very little we knew about Pluto. It’s too tiny and far away to see in more than the



fuzziest of detail from here on Earth. *New Horizons* was designed to bring clarity. For the past nine years it's been speeding across the 4.8 billion kilometres between Earth and Pluto, and later this month it will finally reach its target. The spacecraft carries infrared and ultraviolet cameras and high-energy particle collectors, among other tools. As it sails past at

surface like a chemical factory. It slowly changes slabs of methane ice into a stew of exotic ices, some of which had never been seen anywhere outside of laboratories on Earth. And there are more, with names like Quaoar and Orcus and Sedna and Snow White (don't ask).

I spotted each of these oddballs. And each added to the body of evidence that

yes, but it might take a while to know: Though the *New Horizons* flyby will be over in an instant, the spacecraft speeding on toward interstellar space, the images will dribble back over many months.

For the most part, those images should confirm what we've deduced from the fuzzy pictures taken by ground-based and Earth-orbiting telescopes. Pluto should be relatively smooth, with bright concentrations of frozen nitrogen at the poles and darker regions along the equator. There, methane will have frozen onto the surface and begun decomposing into a deep-red tarlike substance. Charon should look completely different: old and heavily cratered. The ices that move across Pluto's surface, smoothing it out, should have evaporated to space on Charon, thanks to the moon's small size and weak gravity. I suspect we will also see hints of something more going on at Charon's surface, perhaps some regions where ancient volcanic-water eruptions flowed across the moon long after the rest of the surface had been battered.

As a scientist, it's great to have findings confirmed. But it's much more exciting when new questions arise. And *New Horizons* will raise a host. Do frosty geysers dot the surface of an object like Pluto? Can such a tiny atmosphere have weather? Did Charon really have ice volcanoes in the past, and if so, what exactly is an ice volcano, and how does it work? How many meteors have hit these bodies in the 4.5 billion years since they formed? There are many questions to answer, but the most interesting ones will be those we have not yet thought to ask.

Ultimately, *New Horizons* will help us learn how our solar system came to be. That's partly because the ancient surfaces of the Kuiper belt bear the scars of their history far longer than gas planets such as Neptune do. So I'd like to propose a new tagline: "The first mission to the last frontier."

Mike Brown is a planetary astronomer at the California Institute of Technology and the author of the book *How I Killed Pluto and Why It Had It Coming*.

## THE PLUTO OF MY CHILDHOOD IMAGINATION

### WILL BE GONE, REPLACED BY IMAGES OF

### THE REAL THING. AND I'M OK WITH THAT.

50,000 km/h, it will capture images of Pluto and its moon, Charon, in more detail than anyone has ever seen.

For the guy whose discoveries led to Pluto's demotion, the flyby might not seem so exciting anymore. But that couldn't be further from the truth. *New Horizons* is now about way more than just Pluto. It is poised to help us understand a whole new region of the solar system.

Here's why. When the mission was first conceived, we astronomers thought of Pluto as a bit of an anomaly. It is tiny, for one, with an icy, rocky surface—a stark contrast to the giant, gaseous planets that orbit nearer to the sun. But since the launch we've learned much more about Pluto and its environs. And rather than the exception, it seems to be the rule.

Pluto lies at the inner edge of the Kuiper belt, a vast region beyond Neptune. The belt contains hundreds of thousands of 100-kilometre-across bodies, and many more that are smaller. Each has its own quirks. For example, Eris—still the most massive known body in the belt—has an atmosphere that alternately freezes onto the surface and re-evaporates over the course of the 558-year orbit. Football-shaped Haumea spins faster than any other large body in the solar system. Its whirling is the result of an ancient collision that flung icy debris across the solar system's outermost reaches. Makemake has a

Pluto shouldn't count as a planet but rather should be dubbed a dwarf planet. It shares an orbit with its Kuiper belt neighbours, unlike the other things we call planets, which orbit solo. Classifying objects properly is a critical first step to understanding how they work and how they formed in the first place. But not everyone agreed with Pluto's new status, especially in the broader public. To this day I get mail from people asking if Pluto could be grandfathered in to the planet pantheon. (Answer: no.) There's definitely a lot of nostalgia out there.

I get it. I've had a picture in my head since I was in grade school of what the surface of Pluto looks like. On my Pluto, icy spires cast ominous shadows across a dimly lit landscape. You could topple one with a single touch. The sun is so far away, you could blot it out with the tiny cracked shards littering the ground. But after this year, my Pluto will be gone, replaced by images of the real thing. And I'm OK with that. Because *New Horizons* doesn't signal an end but rather a beginning.

As the spacecraft approaches, early images show Pluto and Charon coming into focus as little spheres. We can see the first hints of surface features. Four tiny moons, apart from Charon, have emerged from the planet's glare. As the craft gets even closer, will we discover previously unknown moons? I'd guess

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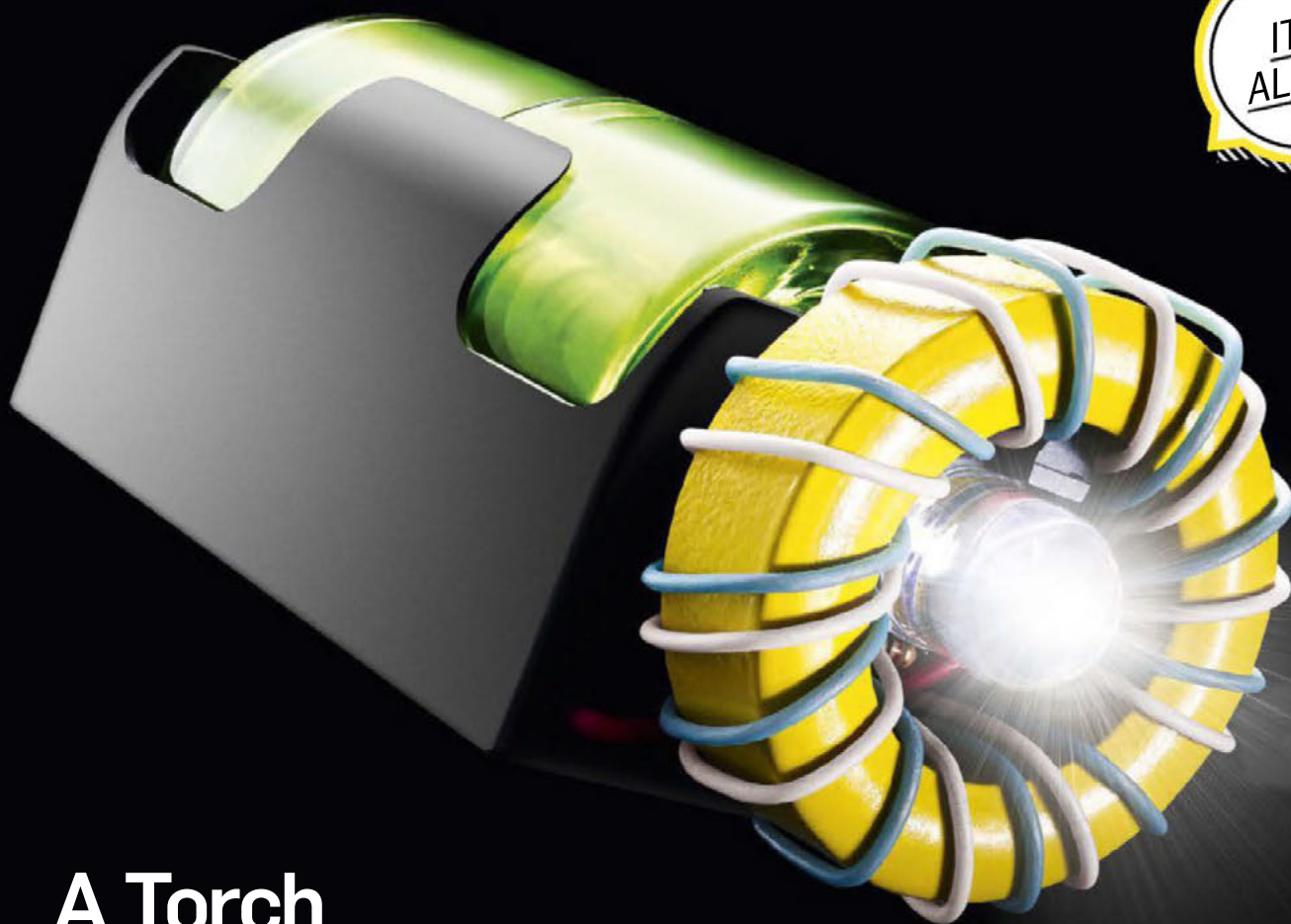
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MA/1507

# Manual

EDITED BY *Sophie Bushwick*



## A Torch That Runs on Dead Batteries



**Don't throw out** that seemingly lifeless battery—it's not dead yet. A brand-new alkaline battery cell has an electric potential of about 1.5 volts, which drops as the juice runs out. The voltage eventually becomes too low to power most devices, but there's still energy trapped inside the battery—as much as 15 per cent of

the original charge.

By wiring a circuit called a "joule thief," (Geddit? Do you geddit? Seriously, do you?) you can tap the last of that power to light a white LED.

The circuit boosts the dwindling voltage but delivers it in pulses too rapid to see. As a result, the LED seems to shine constantly, even

### STATS

**Time** 2 hours

**Cost** \$30

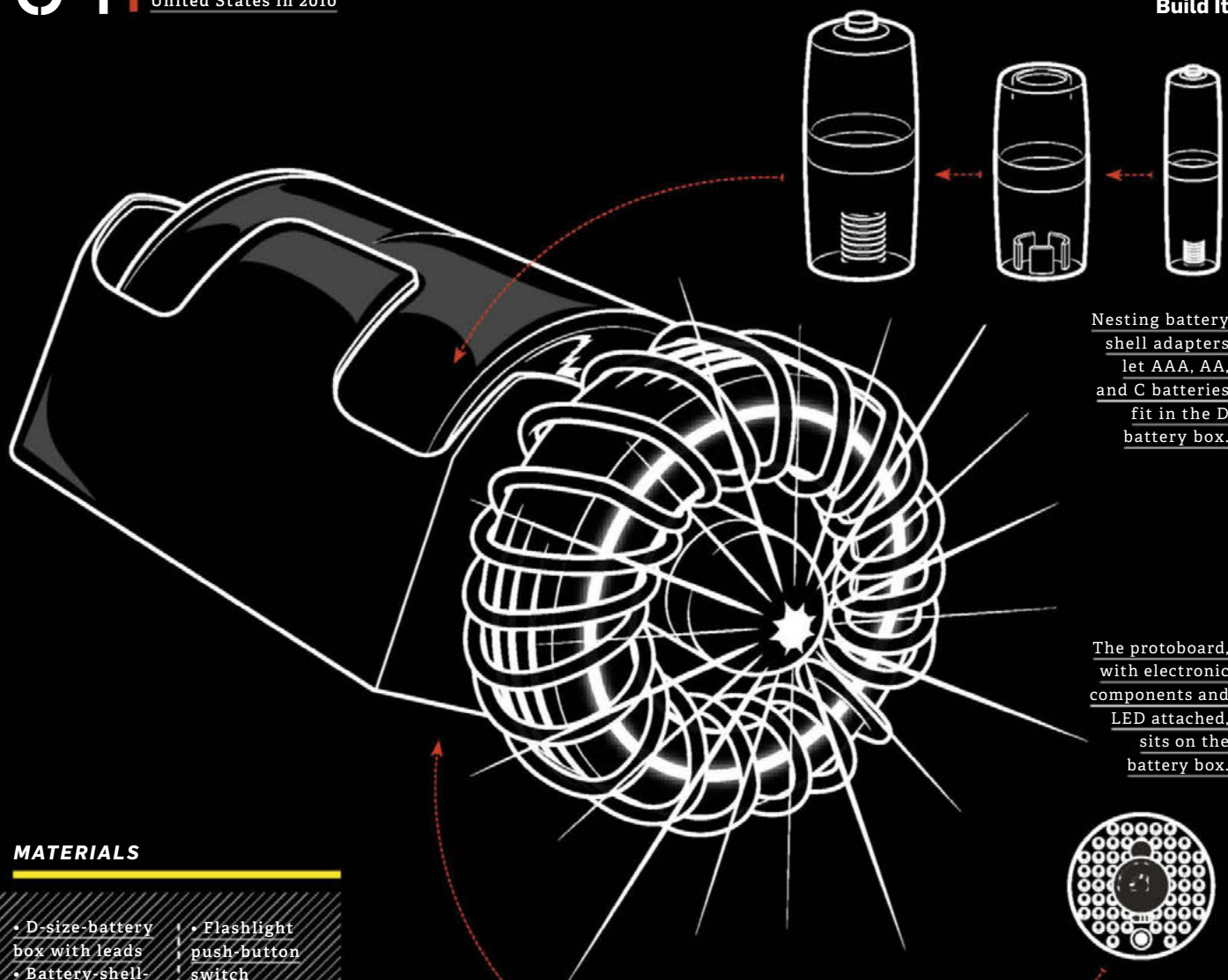
**Difficulty**



though it's really powered less than half the time. Mount the joule thief on a D-size-battery holder, and it makes a handy torch, one that gives your old batteries new life.

SEAN MICHAEL RAGAN





Nesting battery shell adapters let AAA, AA, and C batteries fit in the D battery box.

The proto-board, with electronic components and LED attached, sits on the battery box.

## MATERIALS

- D-size-battery box with leads
- Battery-shell-adaptor set
- 10 mm superbright white LED
- 24-gauge wire from old network cable
- Toroid transformer core, at least 20-mm ID
- Flashlight push-button switch
- 1-kilohm resistor
- 25-mm round proto-board
- NPN transistor
- "Dead" AAA, AA, C, or D alkaline battery

## TOOLS



Soldering iron



Wire strippers



Scissors



Double-stick foam tape

## INSTRUCTIONS

- 1 Loop the battery box's black wire across the negative end of the box, back in the opposite corner, down the long inside edge, and out again on the positive end opposite the red wire.
- 2 Use foam tape to mount the flashlight switch on the battery box's negative end. Cut the black wire below the button, strip the ends, and solder them to the switch terminals.
- 3 Spread the leads on the LED to span three holes, instead of two, and install the light at the centre of the proto-board, soldering the leads underneath.
- 4 Install the transistor on the proto-board just above the LED, and the resistor immediately below. Bend and solder the transistor's emitter to the LED's short lead, its collector to the LED's long lead, and its base to one end of the resistor.
- 5 Cut the battery wires off about 35 mm from the end of the box, and strip the ends. Install the red wire on the proto-board just to the right of the LED, and the black wire immediately to the left. Bend and solder the black wire to the LED's short lead.
- 6 Cut two 500-mm lengths of wire, and strip and tin the ends. Connect one to the red battery lead and the other to the transistor collector.
- 7 Pass the free ends of the wires through the hole in the toroid transformer core. Centre the toroid over the proto-board, with the LED inside, and use the transistor wire to sew it in place, threading the wire through every other hole around the edge. When you've completed a full circle, solder the wire's free end to the red battery lead.
- 8 Repeat with the remaining wire, threading the
- 9 holes you skipped in step 7. Do not cross the wires. When you've made a full circle, solder the second wire to the free end of the resistor.
- 9 Test the circuit by installing a battery in the holder and pushing the button. Once you're sure it works, snip off any excess leads, cover the board bottom with foam tape, and stick it to the positive end of the battery box. Now you can make a dead battery shed light.

205K

Number of mobile phone towers in the US. Statistics for Australia are unavailable.

## EXPLOIT YOUR 4G MOBILE BROADBAND



**Mobile data** - it's a curse and a blessing. It promises so much, but often delivers so little (beyond a shocking bill that leaves you with bill shock). And yet, compared to ADSL2+ struggling through ancient copper wires, the speeds possible are actually very good, provided there is sufficient signal strength.

The boffins over at Telco Antenna did some testing to see what peak speeds they could get from 4G. In Queensland they have 15 MHz of spectrum, so have higher possible speeds than we do in NSW with our 10 MHz of spectrum. The theoretical maximum speed is 151.2 Mbps, and the team managed to hit 88.25 Mbps. That would be an Aussie best, then. Meanwhile, in our own tests with the Optus 4G network in Sydney (on a Nexus 5), we hit 72.5 Mbps.

So why not the full speed? A lot of factors come into play. For a start, it's a shared connection, so the tower bandwidth is spread between all the users - more users, less speed. There is also overhead in the signal transmission, which reduces the available bandwidth below the theoretical maximum. So what do we do about it? Read on! **LINDSAY HANDMER**



### TELSTRA WI-FI 4G ADVANCED II

To put 4G to the test, we got a hold of Telstra premium mobile broadband, uh, thingie. Honestly, we're not sure what to call these. Dongle? Module? Whatever: it can deliver speeds up to 100 Mbps and share to 10 devices via 802.11ac Wi-Fi. It also uses the 700Mhz spectrum and connects to 4GX services. Our test model included 1GB of data, which at full speed could be burnt through in just one minute and thirty seconds. What was that about bill shock?

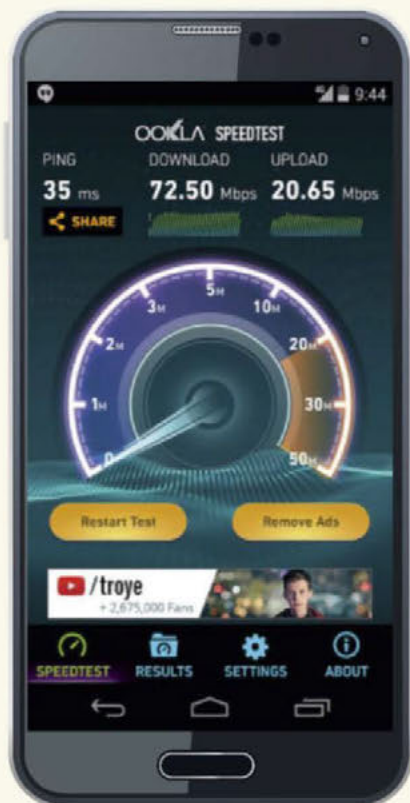
In practice though our speeds were much lower. The average was around 12Mbps, similar to "good" ADSL2+. Peak speeds managed over 50Mbps but we never saw less

than 3.5Mbps.

This compact little broadband modem is built by Netgear and manages an active 11 hour battery life (200 hours on standby) from the 2930 mAh battery. Control is via a touchscreen, and gives access to settings, connections and other features such as passwords. The unit only weighs 136g, and at 68 x 110 x 15 mm, slips easily into a pocket. The modem can also operate as a battery bank to charge a phone.

Of course all this portable high speed data doesn't come cheap and it will cost from \$36 a month for 1GB, to \$120 a month for 15GB. That's what's holding us back. Find out more at [www.telstra.com.au](http://www.telstra.com.au)





## TEST YOUR SPEED!

These speed test apps and websites do the best they can to give you a sense of how fast your connection is. They generally represent an "ideal" situation. Actually accessing real sites overseas may be much slower. Your speed can even be affected by how many people are watching Netflix in Australia at that exact moment.

## BOOSTING MOBILE SIGNAL

Lesser signal quality generally means lower speeds. By boosting the signal, reception can often go from 3G to 4G and gain considerable speed. For those with poor signal strength, there are a number of solutions. The very worst idea is to go onto eBay and buy a mobile boosting station. They are cheap and they work, but they also disrupt the network and cause problems for other users. Not to mention, the networks will track down illegal boosters and fine the operators. And put them in jail for up to two years. Yeah, not worth it. A good place to get started is:

[www.telcoantennas.com.au](http://www.telcoantennas.com.au)



### Legal Active Boosters

The major Telcos in Australia offer their own legal signal boosters. While they do improve reception, they are also pretty expensive and it will cost at least \$1000 just to get started.

### Passive Boosters

With a little work it's actually possible to build a totally passive signal booster. This is especially useful in areas where accessing power is an issue. The system works by using a large, high gain external antenna aimed directly at the nearest cell tower. Inside there is a low gain antenna which rebroadcasts the signal from outside. Such a setup only gives a mild boost, but can be enough to make a difference.

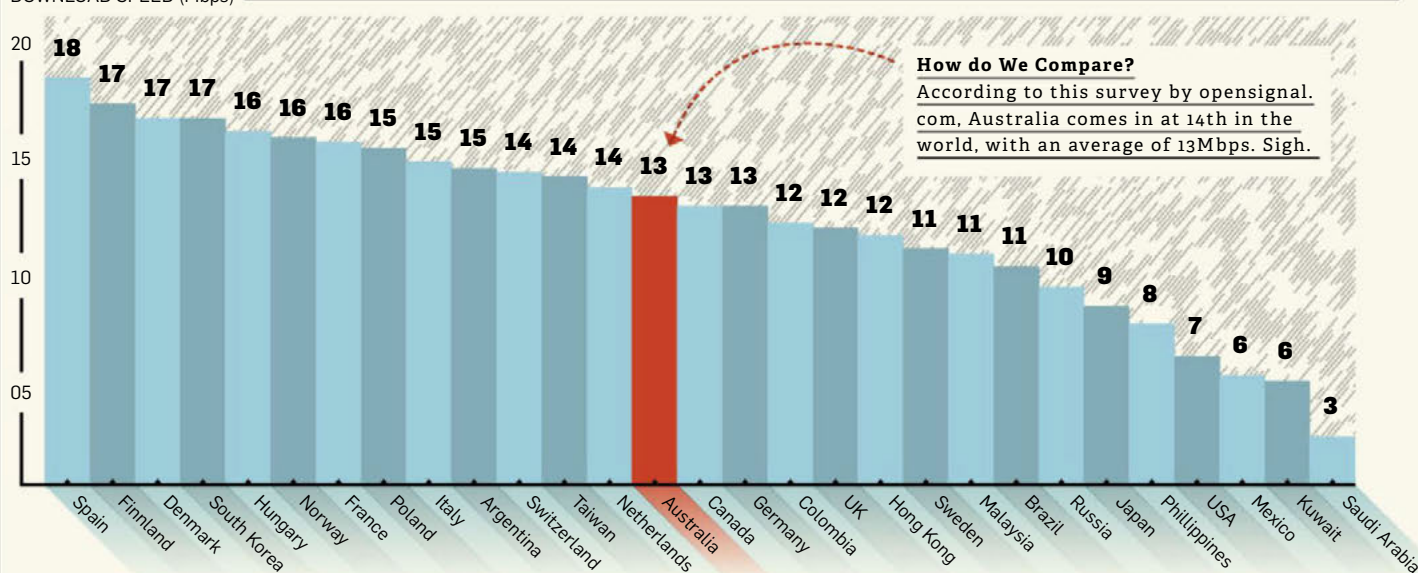
### External Antennas

For some mobile broadband modems, adding an external antenna is as simple as plugging it in. Others don't have any option for an external antenna at all. It's also possible to get external antenna cases for some smartphones to give better reception.

### Go DIY

For modems without an external antenna port, it's easy to build a DIY booster. Using an old Foxtel dish or parabolic metal reflector (many salad bowls and light fittings have the right shape), place the mobile broadband modem at the focal point. Aim the dish at the nearest cell tower to see a noticeable improvement in reception. The dish works by capturing a larger amount of signal and bouncing it towards the modem.

DOWNLOAD SPEED (Mbps)



# Presenting the Apple (II) Watch

## ↓ NOW: SMART WATCH

When the Apple Watch was announced, designer DJ Harrigan didn't sign up for a pre-order. Instead, he built his own: a wearable version of the 1977 Apple II computer. "I wanted to go back as far as possible in Apple history," says Harrigan, "but the Apple II is more iconic than the original."

The 3-D-printed watch, less than 75-mm across, resembles the original full-size machine. (It even includes miniature, nonfunctional floppy disks.) But it's much more powerful. A Teensy 3.1 ARM processor runs at 72 megahertz and has 64 kilobytes of random-access memory (RAM). The screen is a 1.8-inch liquid-crystal display—inconceivable in the late 1970s. The user interface, though, is simple: a knob that winds through several parody apps, including a clock that displays an arbitrary time, a fitness tracker with progress bars that change randomly, and a

weather app—a green, low-resolution picture of Earth.

Harrigan's technological tribute earned the approval of the Internet—and Apple II's creator, Steve Wozniak. As he told Harrigan, "I would buy this over the Apple Watch and would wear it too!"

## THEN: DESKTOP COMPUTER

In the February 1978 issue of *Popular Science*, William J. Hawkins lauded the Apple II's versatility, recommending it for both beginners and experts. A megahertz processor with up to 48 kilobytes of RAM allowed the computer to run the BASIC programming language, as well as machine code. Users could write their own routines, Hawkins said, or use "prepackaged cassette programs, which include everything from games to cheque balancing." **JEREMY COOK**

# 03

Hours of  
battery life  
in the Apple  
II watch



## MAKE THE PERFECT CUT

↓  
**It can be hard** to follow guidelines precisely when cutting wood, especially if you're tracing a perfect circle or punching unsightly knots out of a floorboard. You could solve the problem with a \$10,000 CNC machine, a large device with range limitations. You could risk steering a router by hand. Or you could use the newly developed Shaper, which combines the two tools to cut precise right angles and curves. A would-be carpenter first draws the shape he wants to cut in third-party graphics software. Then he pushes Shaper over the wood. The tool automatically adjusts the path of the cutting bit to match the digital image, amending the line to within 0.2 millimetres. "You can think of it as autocorrect for your hands," says Matty Martin, the designer who created the latest prototype. The Shaper company demonstrated its machines at Maker Faire in May and will begin beta testing this summer, through the website [shapertools.com](http://shapertools.com). **ANDREW ROSENBLUM**

# 1,500

Estimated price of Shaper, in US dollars, when it hits the market



# FROM COFFEE CREAMER TO MUSHROOM CLOUD

DIY-HISTORY COLUMNIST  
**WILLIAM GURSTELLE** GIVES ANCIENT  
WARFARE A MODERN SPIN



In the early morning hours of July 16, 1945, a team of scientists at the Trinity site in New Mexico fretted over a large sphere of steel and electrical cables they called “the Gadget.” A few hours later, the device exploded in the first test of an atomic bomb. It created a flash of light, a roar, and a rising cloud of gas, dust, and debris that has since become the universal symbol of unfathomable power.

I decided to make my own.

Not having access to uranium, I used the next best thing: nondairy coffee creamer. These creamers are mostly flammable fat, and their light, powdery form provides plenty of access to oxygen, creating an explosive fuel.

My mushroom cloud started with a steel juice can. First, I deposited a thin layer of black powder, made up of two fuels—charcoal and sulfur—and an oxygen-supplying chemical called potassium nitrate. This layer has two jobs: ignite the coffee creamer and lift the burning fuel up into the air. Then I added tissue paper, to isolate the black powder until it's

fully lit, and a layer of coffee creamer. Finally I inserted a 6-second length of visco fuse into a hole punched in the bottom of the can.

After donning safety glasses, I lit the fuse and then sheltered behind a tree 10 m away. The fuse set off the black powder, which burned rapidly, ignited the coffee creamer, and propelled it into the air in a giant fireball. As the burning

# 21

Thousands of  
tons of TNT  
required to  
match the  
energy of the  
Trinity test

creamers ascended, it left a vacuum in its wake, which more air rushed to fill. The result was a column of burning gas that was hotter at its centre. Because the hot centre rose faster than the cooler perimeter, the edges appeared to droop, creating the traditional mushroom shape. The roiling cloud, with its bright orange heart, made a beautiful (if ominous) sight on a clear, calm day.

**WARNING:** Attempt this project at your own risk. If you do, then wear safety gear, be careful lighting the fuse, and retreat to a safe place once it's lit. And don't try this in your backyard—mushroom clouds tend to attract the authorities very quickly.





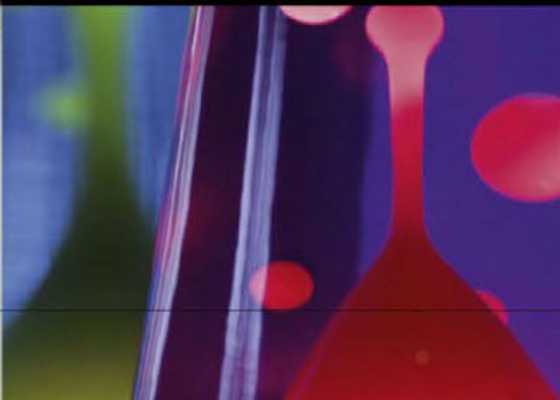


## ADD A MOTION CONTROLLED SWITCH TO... ANYTHING!



A **passive infrared** sensor, or PIR, is the technology behind motion activated driveway lights and some home security systems. And that's usually the only place you find one. But motion control is cool, so how about adding PIR to a less typical device? This Jaycar PIR kit goes between your gadget and the powerpoint and adds motion control with the (possibly ironic) flick of a switch. Activate fans, heaters, lights, cameras, music, fountains, amusing singing fish, or more. The world is your PIR controlled oyster!

LINDSAY HANDMER







The Jaycar motion switch is fairly simple - a PIR sensor detects movement and switches 240V to an output. There are two plugs included, though if your device comes in under the power rating, adding a powerboard is also fine. The onboard relay is rated at 20 amps, so will have no trouble with typical appliances, though of course you shouldn't connect multiple high current gew-gaws like heaters, driers, scanning electron microscopes etc.

#### STATS

**Time:** 4 Hours

**Price:** \$79.95

**Kit Code:** KC5455


[www.jaycar.com.au](http://www.jaycar.com.au)

**Difficulty**



The kit has an adjustable "on" time, with 10 different settings from a few seconds up to 128 minutes. There's also an override button to trigger the circuit in the old school way.

While the kit runs from the wall via the included transformer, it's actually possible to power it from any 12V source or even from batteries. The output relay can also be used to switch other voltages, up to 240V.

Oh, something we should have mentioned at the top of this paragraph: an actual PIR sensor is not included in the kit. It uses any standard model from an old alarm or motion sensing light, or you can grab a new one for \$5 on eBay. 

## Passive Infrared Sensor

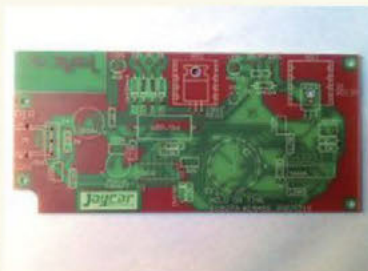
So how do these actually work? Everyday objects emit infrared radiation that is invisible to the human eye. A room is typically a uniform temperature, but when a person walks in, infrared radiation spikes. The PIR senses this change with a film of special pyroelectric material (such as gallium nitride) which generates electricity when exposed to heat. From there a circuit is triggered, which can be used to set off an alarm or turn on a light. Or a singing fish.

## THE BUILD



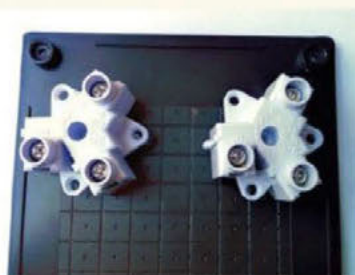
### Step 1: The Components

The PIR-triggered switch is a fairly simple circuit, but includes a lot of extra wiring to switches, lights and power plugs. Take extra time to familiarise yourself with the instructions as there are more custom mounts than usual. You'll also need extra tools such as a drill and cutting knife.



### Step 2: The Circuit

Soldering together the circuit is relatively simple. Make sure there is good contact between the transistors and their heatsinks. As usual, double check the ICs are installed in the correct direction and location before powering on up. Extra care needs to be taken when attaching the LEDs so they are the correct height to poke through the lid.



### Step 3: The Box

The good news is that the included jiffy box has all the needed mounting points pre-drilled and cut out. Take care in construction to ensure everything is well mounted. In particular, make sure all live sections are suitably insulated according to the instructions. If in doubt, check with a multimeter.



### Or Try This: 12V Option

A mains-powered PIR kit is very versatile, but sometimes it's desirable to just switch 12V without building a big kit. The mini PIR module is perfect for setting up motion activation in cars, boats and caravans. There's no construction required. Just give it 12V via a standard 2.5mm DC plug, connect up the included PIR sensor and it's good to go. The module includes a separate 12V input and output with sockets to secure the wires. It can switch 12V DC at up to three amps, so is perfect for running LED lighting strips. On-time is preset to 30 seconds, and can't be adjusted. The PIR sensor has a 1.5m cable and detects movement with a 1-3m range. The entire unit is just 6 x 4 x 1.8 cm and includes screws and mounting holes.

Catalogue Number: ST3940

Price: \$21.95, [www.jaycar.com.au](http://www.jaycar.com.au)

## SAFETY WARNING



This kit runs at mains voltage and extra care is needed in construction. Never open it or poke it with a metal object while plugged into a 240V source. Obviously.

## Cheap Tricks

## Blow Safer Smoke Rings



**You don't have** to take up bad habits to blow smoke rings. On the YouTube channel DaveHax, life hacker David Haxworth simply uses a balloon, an incense stick, and a plastic bottle. "I first saw the homemade smoke rings idea on a TV show when I was a child, and I remember thinking it looked like great fun," Haxworth says. The balloon propels puffs of smoke through the bottle's mouth, creating picture-perfect smoke rings—no inhalation required. **RACHEL FOBAR**

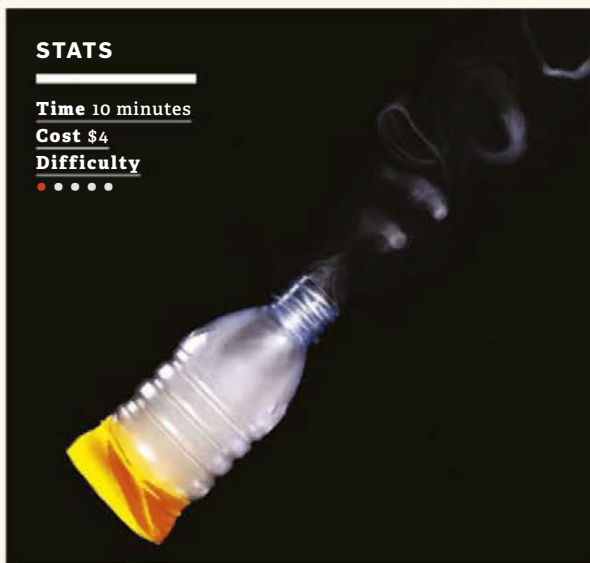
## STATS

Time 10 minutes

Cost \$4

Difficulty

● ● ● ● ●



## MATERIALS

- Plastic bottle
- Balloon
- Incense stick

## STEPS

1. Use scissors to cut off the bottom off a dry, empty plastic bottle, while taking care not to slice your skin on the sharp plastic.

2. Cut off and discard the narrow mouth of a balloon. Carefully stretch the balloon over the bottom of the bottle until it's taut.

3. Light an incense stick with a match or lighter, and then blow it out. Hold the smoky end inside the bottle, covering the opening.

4. Once the bottle has filled with smoke, remove the stick. Lightly tap on the balloon end of the bottle to produce an authentic smoke ring.

## Killer App

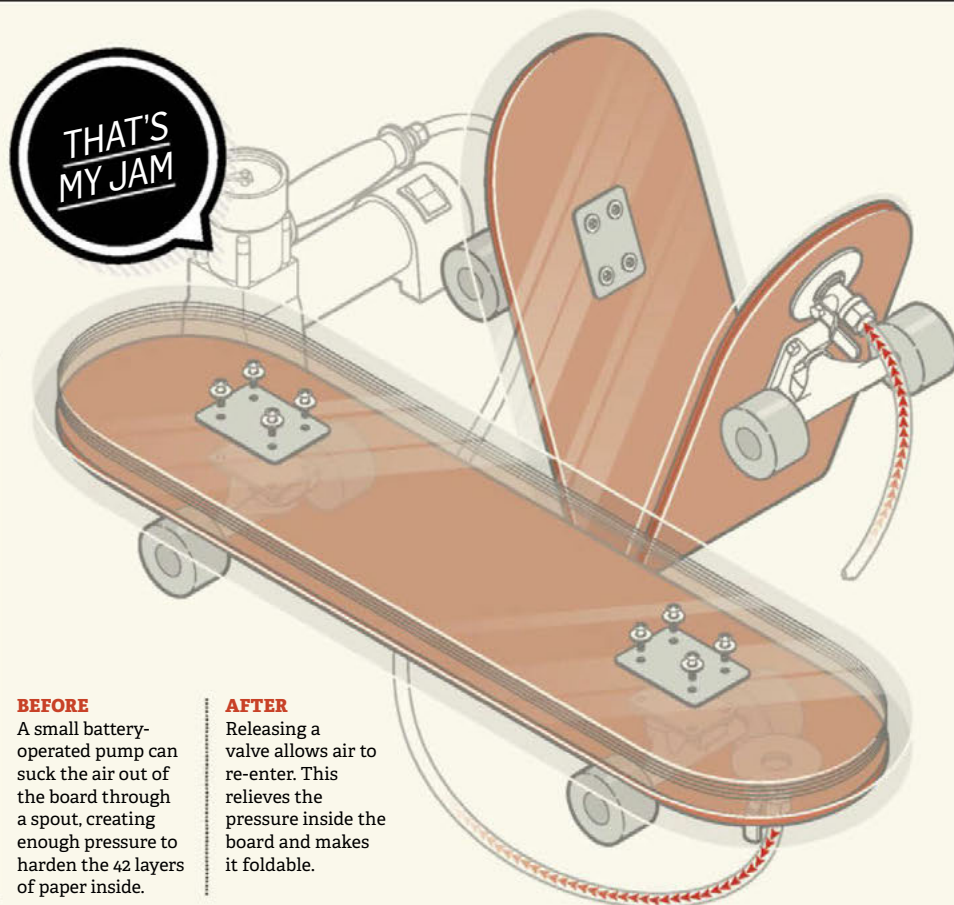
## ROBOT SCHOOL

**In the iOS app** *Robot School: Programming for Kids*, players 7 and up help a stranded robot refuel its spaceship and return home by steering it through 45 levels. As they play, the game teaches them how to program, demonstrating techniques such as procedures, loops, and conditional instructions. Players can view the code they created after completing each level and even share it on Facebook. "We are already living in a world dominated by software," says Agata Kozak, project manager at educational app developer Next Is Great. "Teaching coding helps kids understand the technology they are using." That knowledge isn't just handy for kids, Kozak says: "We encourage grown-ups to try it out too!" **RACHEL FOBAR**

## This Skateboard Folds in Half



**For their final** engineering-class project, a team of students at the University of Colorado at Boulder decided to create a jammable material, a flexible substance that acts solid when put under pressure. Juniors Fai Al Mulla, Seth Zegelstein, Sam Oliver, and Justin Olsen tried four different prototypes, and the one that worked best was also made from the cheapest material: construction paper. Layers of the paper could be jammed, or made rigid, if the students sealed them between pieces of plastic and applied pressure by pumping out the air. That experiment soon led to "flappy board"—a skateboard that can be folded in half. "The idea behind this project was for the skateboard to be portable," says Al Mulla. Redundant? No: by folding up the board, users can stash it in a backpack between rides. **ALEXANDRA OSSOLA**

**BEFORE**

A small battery-operated pump can suck the air out of the board through a spout, creating enough pressure to harden the 42 layers of paper inside.

**AFTER**

Releasing a valve allows air to re-enter. This relieves the pressure inside the board and makes it foldable.



## FIGHTER PLANES DEFEND THE HOME FRONT



In early 1941, the United States had yet to enter into World War II, but weapons and warplanes were already a topic of national interest. One of those planes was the F4F-3 Wildcat, which the Naval Air Force deployed to monitor the coasts. The fighter, which graced the February 1941 cover of *Popular Science*, could drop 100-pound (45 kg) bombs while flying at speeds greater than 400 km/h. As we wrote then, "Perhaps our patrol bombers and flying fortresses can't send capital ships with heavy deck armour to the bottom, but they can certainly send them to dry dock, back where they came from." Aviation technology has advanced significantly in the 70 years since World War II, and it stands to change even more. Future air battles will likely be fought by unmanned craft carrying much heavier artillery. To read about the weaponry, airborne and otherwise, being developed for new global conflicts, turn to page 54.

RACHEL FOBAR



# 7,885

Number of F4F-3 Wildcats built

## AERIAL FACE-OFF

**F4F-3** (retired 1945)

**Top Speed** 527 km/h

**Top Altitude** 37,500 feet (11,430 m)

**Weapons** Four .50-inch machine guns and two 100-pound bombs

**Weight** 3,697 kg

**Cost Per Plane** \$30,000 (\$395,000 today)

**F-35A CTOL** (in development)

**Top Speed** 1,930 km/h

**Top Altitude** 50,000 feet (15,250 m)

**Weapons** 8,150 kg total payload, including laser- and GPS-guided bombs and air-to-air missiles

**Weight** 31,751 kg

**Cost Per Plane** \$108 million

Go Ahead...

# Ask Us Anything

ANSWERS BY **Daniel Engber**  
ILLUSTRATIONS BY **Jason Schneider**

Have a burning question? Email it to [letters@popsci.com.au](mailto:letters@popsci.com.au) or tweet it to [@popsciau](https://twitter.com/popsciau) #AskAnything.



## Q: DOES SUGAR MAKE KIDS HYPER?

**Short answer** Only if you believe it does.

**A:**

**The image of a kid** on a sugar high bouncing off the walls gained credence in the 1970s and '80s, when several studies linked sugar intake to behavioural problems such as hyperactivity - whatever that means.

But in 1995, Vanderbilt University pediatrician Mark Wolraich reviewed 23 studies involving more than 400 children and found no evidence for the belief that sugar impacts a kid's behaviour or cognition. "We came as close to proving the null hypothesis as you can," says Wolraich, who is now Chief of Developmental and Behavioural Pediatrics at Oklahoma University.

In the early 1990s, psychologists

Richard Milich and Daniel Hoover took a different approach to answering the question: They studied 31 boys ages 5 to 7 whose parents identified them as "sugar sensitive." The researchers gave the boys fake-sugared Kool-Aid and then videotaped them interacting with their mums. Beforehand, the researchers told half the mums their kids had consumed sugar and told the other half the truth. Parents who thought their kids were on a sugar high rated them as being more hyperactive and criticised them more severely. Milich and Hoover concluded that the link between sugar and behaviour might be based on parents' expectations, not on the sweetener itself.

There might also be other factors at play when sugared-up kids go nuts. Lollies and cake, for example, are staples at birthday parties—events rife with kid drama. Or there might be other substances in the mix. Chocolate, for instance, is packed with stimulants, including caffeine.

Still, for many parents, sugar remains the go-to scapegoat, even if proof is lacking. "We're always looking to explain our behaviour," Milich says. "We don't like to be in a vacuum where something happens and we don't know why."

## Q: WHAT'S THE DEAL WITH PARANORMAL ECTOPLASM?

**Short answer** It's spiritualist bunk that reflected the science of its time.

**A:**

**Nineteenth-century physiologist** Charles Richet first used the term ectoplasm to describe a strange material that seemed to flow from spirit mediums during a séance. Doughy strings appeared to ooze from their bodies and make ghostly faces or disembodied limbs.

Of course, these ectoplasms were a parlour trick. Mediums used sleights of hand to present gauze and animal parts as spiritual phenomena. As silly as this now seems, many intellectuals of the time found the shows convincing, including Richet, who won a Nobel Prize for his pioneering work on anaphylaxis. "Richet was no dummy," says Robert Brain, a historian of science at the University of British Columbia. Yet Richet was dogged in his studies of paranormal ectoplasm. "What made ectoplasm seem plausible to otherwise rational, clear-headed scientists?" Brain asks. "There had to be an underlying logic to it."

He's right. By the mid-1800s, scientists had discovered a gelatinous substance or "plasm" inside plant and animal cells, which they believed to be the basis for all life on Earth. "Biologists were actively interested in protoplasm for 100 years," Brain says. The concept was mainstream.

With this in mind, it might not have seemed so strange for the body to extrude plasm under exceptional circumstances. Or for that external protoplasm—called ectoplasm—to change form. Eventually modern molecular biology revealed that heredity is stored not in the vibrations of a cell's jiggly plasm but in the acids of its nucleus. At that point, "protoplasm became an embarrassment to biology," Brain says.







## Q: Does hitting snooze help or hurt?

**Short answer** Depends on when you hit it.

**A:**

**Sleep that gets** interrupted throughout the night can leave you sluggish and inept after you wake up. By the same token, the stretch of morning ups and downs caused by repeatedly pushing your alarm clock's snooze bar could have deleterious effects. "You're probably getting worse sleep during those 30 minutes [of snoozing] than

you would if you just set your alarm 30 minutes later," says Jeanne Duffy, a neuroscientist and sleep researcher at Harvard Medical School.

But snoozing could still have its benefits. Duffy has looked at "sleep inertia," or the drowsy, distracted feeling (and physical weakness) that can linger after you wake up. The amount of sleep inertia you experience depends, in part, on the stage of sleep from which you're jerked awake.

If you're stirred from the deepest stages of slow-wave sleep, "you might have no idea where or who you are," Duffy says. In that case, it might help to snooze some minutes more.

That way you can reawaken from a different stage of sleep, such as REM, when your body is closest to its wakeful state. "It might make things better," says Duffy. But if you're in REM already, snoozing could send you deeper and make things worse.

## Q: WHY IS CANDY CRUSH SO ADDICTIVE?

**Short answer** It's easy to learn and hard to master.

**A:**

**This mobile game** has generated billions of dollars (and perhaps as many hours of wasted time) since its release, in 2012. What's the secret of this procrastination juggernaut? "It's very easy to learn," says Jesper Juul, who has written a history of this simple and addictive genre of games, known as Match-3.

*Candy Crush*, like other Match-3 games, uses a grid of tiles in various colours and shapes. Players swap those tiles to make matching stripes of three (or more) tiles, which then vanish with a satisfying whoosh. But



Juul says it gets surprisingly hard, level by level, to clear each board of tiles. A group of computer scientists in Rome proved last year that the course a Match-3 game will take is exceedingly difficult to predict.

If the game were too hard, players would just give up, so Match-3 games lure users with lots of tiny victories. You

can't make a move without getting a match and clearing tiles, so every turn delivers a jolt of positive feedback. Another factor, says Juul, is the lack of time pressure, which allows users to play distractedly, on their own time.

*Candy Crush* is not the first game to cash in on these qualities. Match-3s first gained popularity in 2001, with the release of *Bejeweled* (sic), which uses gems in place of lollies. The makers probably got the idea from the simple Russian game *Shariki*, released in 1994.

If you follow the lineage all the way back to the 1980s, you'll arrive at what Juul calls the "primordial" matching tile game: *Tetris*.

The addictiveness of Match-3 games might not be inherent to their design, though. It's likely more about trends. Juul points out that the genre's popularity fluctuates in tandem with complex games like *World of Warcraft*.

"It's popular because it's popular," says Juul. "It becomes a cultural moment ... that would have been impossible to predict."

# Metal Storm

What ever happened to this radical rethink of the traditional firearm? **LINDSAY HANDMER**

↓  
**Back in the 80's** an Aussie inventor named J. Mike O'Dwyer decided to revolutionise modern weaponry. He sold his business to pour everything he had into a radical invention: Metal Storm. His mistake? Trying to change the military industrial complex in the middle of the longest peace since the

**6000**

Max rate of fire, in rounds per minute, of a traditional 7.62 x 5mm minigun, as used in the Vietnam War.

Pax Romana. His fate? Read on.

O'Dwyer wasn't satisfied with the way most guns worked and figured he could make them fire faster. As in, a million rounds a minute faster. That's where the name Metal Storm came from. It was no mere gun, shooting mere bullets. It was a wall or cloud of projectiles that could shred anything and everything in its way. Not only could it deliver a crazy amount of destructive force to a single target, thanks to computers, the system could fire a spread of projectiles that could easily take down an incoming missile, or even an artillery shell.

To achieve its insane firing rate, Metal Storm used what's called a superposed load. To explain: a tube

is stacked from end to end with projectiles, all of which have their own propellant and a teeny bit of smarts via a chip. Using a computer, trigger them off very quickly one after each other and the result is a gun that discharges its entire magazine almost instantaneously.

When you group 36 of these tubes - or barrels - together into a minigun, Metal Storm can fire 180 rounds in just one hundredth of a second (a human blink takes 0.3 seconds).

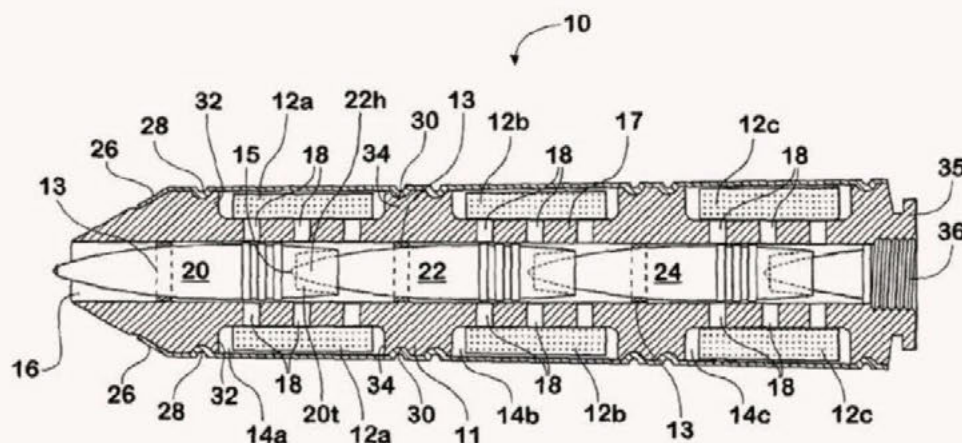
Unlike a giant shotgun, which more or less does the same thing, Metal Storm is very controllable. The fire rate can be increased or decreased depending on the target, and each bullet can be controlled individually.

An immediate challenge with su-

Metal Storm wasn't just designed for offence. Its rate of fire was so high, and its aim so accurate, it could shoot down incoming missiles or even artillery shells. At least, on paper. Making it work remains a challenge... or does it? Aren't black defence budgets fun!







In a superposed weapons system, each round can be fired simultaneously, or equipped with some kind of control system to moderate the rate of fire. Metal Storm used electronics for extreme flexibility.

perposed loads is that firing off the first projectile can, by its heat, set the one off below it and so on in an uncontrolled explosion. Metal Storm gets around this limitation by using an innovative system where the firing of each round pushes the round below backwards hard enough to prevent "cooking off" or uncontrolled discharge. Importantly, O'Dwyer also developed a way to electronically trigger each bullet to ensure the proper firing sequence.

After more than a decade of development, Metal Storm (the company) successfully tested Metal Storm (the technology) with a 36 barrel prototype.

O'Dwyer got in touch with the Australian Department of Defence at this point, but according to media reports in the late 90s, they brushed him off. O'Dwyer didn't give up though and, like so many Aussie entrepreneurs, turned his eye to the east, and eventually caught the attention of the US Military.

According to the copious amount of folklore that now surrounds the Metal Storm story, China also had its eye

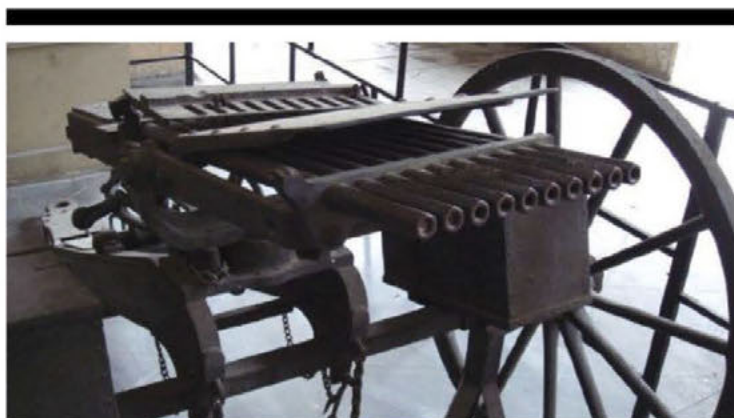
on the technology, and, as the story goes, offered O'Dwyer \$100 million to develop Metal Storm for China instead. Like any patriotic Aussie, O'Dwyer turned the money down and the Commonwealth government was duly informed. Of course, we're led to believe China developed its own version of a superposed, computerised weapon system anyway. Word has it the PLA even called the program Metal Storm.

Meanwhile, Metal Storm (the company) went on to develop technology that could be used by firefighters, and received at least some funding from the US military. Other versions of the guns were developed too, such as a handgun, grenade launcher and non-

lethal ammunition. It also appeared in various turn-of-the-century Sci-Fi novels, including John Birmingham's weird (but cool) time travel epic *Weapons of Choice*.

Pop culture and forest fires weren't enough though and O'Dwyer eventually left the company (and technology) he started. Metal Storm soldiered bravely on without much funding, but by 2012 the company had shut up shop and went into voluntary administration. As far as we know, Metal Storm is no more. But still, you know how it is with the military industrial complex: don't be surprised if you see this technology deployed at some point in a future conflict.

And as the lawyers gather to prosecute another round of war crimes, just think: that horrific thing was a proud Aussie invention. 🇦🇺



### THE NORDENFELT GUN

Nothing is new, right? Metal Storm has a great great grandfather from back in the late 1800s. The Nordenfelt Gun had up to 12 barrels, ranging from rifle sized up to a 24mm monster. A kind of horizontal mini gun, it didn't load up the barrels with superposed loads, but did fire from each one multiple times. Hand cranked, the Nordenfelt could fire up 1000 rounds a minute. Eventually it was outclassed and replaced by the more conventional Maxim gun that used recoil to load each round.

### SUPERPOSED LOADS

The Metal Storm concept has actually been around for a long time. But until the advent of integrated circuits, the trick was making it actually work in an accurate and reliable way. The cracker-night favourite "Roman Candle" firework is an example of a superposed load. The cardboard barrel is filled with delayed charges, and each triggers the charge below. As early as the 1500's, guns were made that followed the same principle. Eventually, more sophisticated models were developed that could fire off 20 individually triggered bullets per barrel, in about 40 seconds. Metal Storm takes this concept to a new level though, with five bullets per barrel fired in just one hundredth of a second.



# Next Issue

August 2015 - On sale 30th July

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